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REEF CORALS

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A HANDBOOK OF THE COMMON REEF AND SHALLOW-WATER CORALS OF BERMUDA, FLORIDA, THE WEST INDIES AND BRAZIL

by

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CONTENTS

PLATES

TEXT FIGURES

PREFACE

THIS HANDBOOK represents an attempt to satisfy the requirements not only of collectors of corals, both casual and experienced, but also of the biologist who chooses to work on these inhabitants of the warm shallow seas of the Western Atlantic shores.

Corals have always been of interest to scientists but in addition they have a much wider appeal since they are among the most beautiful and spectacular of the tropical sea animals. The shores of Bermuda, South Florida, the Bahamas, and the West Indies and the Western Atlantic coast as far south as Brazil generally abound with a variety of these species, which are sought after by collectors. Not only the collector, but the casual observer, too, is frequently interested in knowing more of the life of the coral animal, the way the coral rock is formed, and how to name the specimens he finds. For these reasons it seemed desirable to prepare an accurate but non-technical account of the corals. Care has been taken to illustrate it with photographs since these are not only helpful in the rapid identification of specimens, but also serve to show the beauty of design inherent in the coral structure.

Corals interest the scientist for many reasons. They grow in tropical waters which have been much less thoroughly investigated than the colder ones. They also offer many fascinating problems in physiology and structure as well as in their relation to the surroundings. Many of our rocks are composed principally of microscopic animals such as the foraminifera whose activities millions of years ago produced the great limestone cliffs

and chalk hills which exist in many parts of the world today. In some ways, however, corals surpass the foraminifera and are the most spectacular rock builders of all. For this reason they are quite as interesting to the geologist as to the marine biologist and oceanographer. By their presence he is often able to deduce the former history of the land and the rocks.

In order to study the living coral it is first of all necessary for the scientist to distinguish between the bewildering number of different species. Unfortunately, most of the authoritative publications in this field are written by museum specialists from a purely specialized taxonomic point of view. Little has been done to make it easy for the physiologist or ecologist or the non-scientific collector to identify his coral material. The Western Atlantic corals have been the subject of many publications, but the literature is scattered and almost entirely out of print. For these reasons, scientists working in the West Indies generally and at the Marine Laboratory of the University of Miami in particular have long felt the need for a collected account of the corals, with simple directions for their rapid identification which would not involve the necessity for a considerable preparatory study of the detailed characteristics of the group.

It is sincerely hoped that the requirements of both types of reader will be met. Technical language has been avoided and description has been kept to the simplest terms possible. To meet the needs of students interested in further study, however, a technical key to genera and a carefully selected bibliography are included.

Grateful acknowledgement is made of the assistance

rendered by members of the Marine Laboratory staff in preparing this handbook, of the kindness of Drs. Wayland Vaughan and John Wells in giving advice on taxonomic problems, and of the generous help given by Mr. C. S. Daniels. Thanks are also gratefully accorded for the efforts of the many faculty members and students who have helped to collect the corals in the Marine Laboratory's reference collection from which most of the photographic illustrations in this book were made. For the photograph of *Meandrina brasiliensis* we are indebted to Mr. Frank Lyman, who kindly loaned his specimen for the purpose.

1. DISTRIBUTION OF CORAL REEFS THROUGHOUT THE WORLD

CORAL REEFS are found throughout the West Indies, forming barriers just beneath the surface of the water, where they are a hidden menace to navigation. They are most beautiful to look at on a calm day especially if one is able to peer down at them through a glass-bottomed bucket or through the glass faceplate of a shallow water diving helmet. Some form large boulders covered with intricate patterns traced in green and gold. Others form tree-like growths, fancifully resembling antlers of deer or elk. Smaller corals grow between these and appear as multicolored flowers, among which brightly hued tropical fish wander. Nevertheless, on other days, when the ocean is no longer calm, the sharp edges of the coral lie in wait for the careless navigator to rip through the hull of his vessel. The West Indian reefs have a plentiful record of wrecks, many dating back to the days of the Spanish treasure fleets. Although hidden today by a heavy overgrowth of coral some of these fabulous prizes still show their presence by an occasional doubloon or gold ornament washed up on the beach.

Corals are by no means restricted to the West Indies. Certain small corals are present in every ocean in shallow depths while others are found in great depths far from shore. They may even be dredged from the cold seas lying within the Arctic and Antarctic Circles. In the deep water of the Norwegian Fjords, for instance, a delicate branching coral with orange colored fleshy

"flowers" on its interwoven twigs has been dredged from a depth of over one thousand feet. Along the rocky shores of the United States, Canada and the coasts of England and France there are found simple corals in the form of tiny individual cups. None of these cold water corals, however, grows so actively or to such a size as the reef corals of the tropics and their form is always small and delicate rather than large and massive.

True reef corals, which individually may reach a size of several feet across, are never found in great depths or in cold water, but always in fairly shallow depths near tropical shores. Even in the tropics they are not found universally, but only in certain well defined areas. These areas are situated within a belt roughly bounded by the tropics of Cancer and Capricorn, imaginary lines which are drawn around the earth 23½ degrees north and south of the equator and which mark the northern and southern limits of the sun's movement during the year. Within this 3,000 mile belt coral reefs are abundant on the eastern shores of continents such as the West Indian Islands and Brazil on the American continent, and from the Red Sea to Madagascar on the eastern side of the African continent. They form a gigantic series of barriers known as the Great Barrier Reef off the northeastern shores of Australia and are dangerous to navigation throughout the South Seas and the tropical Pacific Islands. Coral reefs lie under the breakers off island shores in the Indian Ocean and in the Atlantic are even found as far north as Bermuda. But they are absent from the western shores of continents. California and Western Mexico have no true reefs and the West Coast of Africa is also free of these

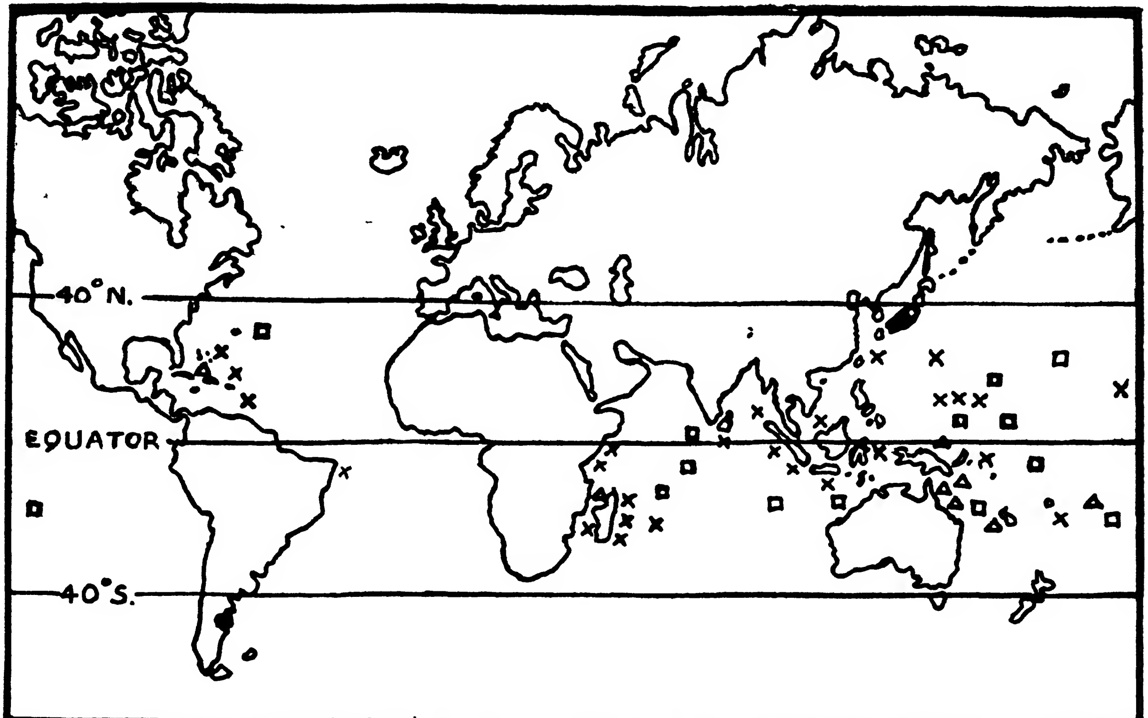

Figure 1. Map showing distribution of coral reefs throughout the world. x fringing reefs. Δ barrier reefs. □ atolls.

dangerous but beautiful outgrowths of the ocean floor.

Such a patch-work distribution seems at first sight random and meaningless. The investigations of many scientists over a number of years, however, have shown that there is really a logical arrangement in it, and that the apparent lack of order in the location of coral reefs represents in reality a combination of definite requirements of the individual coral as to living conditions and a very definite pattern in the distribution of these desirable conditions throughout the world.

One of the major requirements of the reef corals is that the temperature of the surrounding sea water should not drop below 20° Centigrade or 70° Fahrenheit by more than a few degrees or for more than a short time. Prolonged exposure to slightly lower temperatures or shorter exposure to much reduced temperatures result in the death of reef corals.

While some corals are perfectly capable of living under conditions of sedimentation, the true reef corals are easily killed by mud or sand which may settle upon them in roily or still water. Corals of the massive boulder type are frequently found to be dead on the upper surface where sediment naturally collects, while still growing on the outer edge and sides. In extreme cases this may result in the growth of a doughnut shaped boulder.

Although it is an animal, the reef coral always contains within itself algae or small plant-like cells. Plants require light in order to live and it is believed that the oxygen produced by the algae is necessary for maximum growth of the coral. Possibly because of this, the reef corals and their contained algae are able to flourish in strong sunlight only.

The living coral is a carnivorous animal and feeds upon small floating or swimming creatures which it captures by means of stinging tentacles, and by means of a slimy secretion of its skin. Since the coral is unable to move in search of food it follows that in order to flourish it must be exposed to water currents or wave action which will bring food to it.

The degree of salinity of the seawater is a further factor of importance to the coral. Salts in ocean water are in a concentration of about 35 parts per thousand. When this is reduced to less than 25 parts per thousand the reef coral begins to suffer. Similarly an increase of salinity to 40 is harmful to many corals.

The tropical zones with seawater temperatures ranging from 25° Centigrade to 30° Centigrade (75° Fahrenheit to 85° Fahrenheit) contain the only areas where reef corals are able to flourish at their maximum. Since the ocean currents are forced into a clockwise spiral movement by the earth's rotation and associated wind distribution, warm water travels towards the poles along the eastern shores of the continents. On these shores, therefore, there is a much wider extension of warm water suitable for vigorous coral growth. On the western shores of continents the reverse is true. Cold currents of water running towards the equator, combined with upwellings of cold water from the depths, greatly restrict the extent of shoreline favorable to coral growth. Thus it is that reefs are for the most part formed only upon the eastern shores of continents, and in the open tropical seas.

Sunlight is rapidly absorbed as it passes into seawater. The requirement of strong sunlight therefore restricts reef building to depths of less than 150 feet

and vigorous reef growth only takes place within 90 feet of the surface. Possibly the need of water currents to bring food and of wave action to provide oxygenation are also involved in restricting vigorous reef growth to these depths. In deep water, where wave action and currents are less effective or absent, sediment may also prevent coral growth.

The adverse effect of sediment is most pronounced in sheltered water. In shallow water near shore there is also likely to be excessive evaporation leading to unduly high salinity, or land drainage of fresh water which results in dangerously low salinity. These factors, together with the need for wave action account for the restriction of vigorous reefs to the windward sides of islands and for the greater growth of coral on the seaward side of the reef where it is completely exposed to heavy seas.

2. MANNER OF FORMATION OF CORAL REEFS

ALL CORAL REEFS are built in a similar manner, by the growth and accumulation of stony skeletons of the coral animal, but they are not by any means the same in general appearance and structure. There are, in fact, three main types of reef. The kind known as a fringing reef is found quite close to the shores of continents or rocky islands in shallow water. In contrast to this a barrier reef is usually separated from the shores of the mainland by a channel many miles wide and as great as 175 feet in depth. The third type, known as an atoll is not connected with any land mass but rises to the surface as a low island, roughly ring-shaped and surrounded by water several thousand feet deep.

The fringing reef is formed by corals growing close to the shore in shallow water. As they increase in size and number they grow towards the surface and also outwards in the direction of the open ocean. This is a consequence of previously mentioned living requirements of the reef corals, which flourish at their best where wave action is strong. Similarly the corals between the outer edge of the reef and the shore tend to die as a result of increased temperature and salinity changes, and of deposition of sediment. The net result of growth at the outer edge of the reef is shown in figure 2. A broad platform of partly living and partly dead coral rock is formed, extending horizontally from the shore. At the outer edge is the living and actively

growing part of the reef, which slopes steeply downward on the ocean side. The edge is separated from the land by very shallow water and at low tides the entire platform is almost exposed. Unless large scale movements of the land take place the reef is limited in its sea ward extension beyond a point where its base has reached a depth of about 100 feet. This is due to the fact that vigorous coral growth cannot take place in depths greater than this. A certain amount of seaward extension may take place, however, as the result of broken coral rolling down to the foot and building up a base of dead rock upon which new growth may occur.

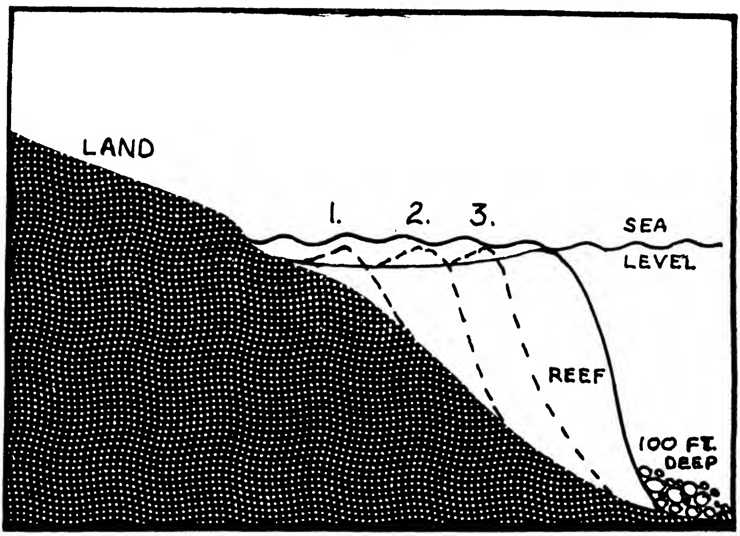

Figure 2. Section of a fringing reef illustrating the manner of development. Not to scale. 1, 2, 3, successive stages of growth.

Fringing reefs are found on the shores of the east coast of Africa, Madagascar, Java, the Solomon Islands and the Carolines. Poorly developed reefs of this type also occur in Hawaii. The reefs of Florida and the West Indies have been described as fringing reefs but they

differ in many respects and are by no means typical. They are therefore considered separately in the next chapter.

Barrier reefs present an entirely different appearance, and are both complex and extensive. The most striking example is the Great Barrier Reef of Australia, which has been well described by Yonge (1930) and others and which was the subject of a special expedition in 1928. The Great Barrier Reef consists essentially of a line of reefs running parallel to the mainland and separated from it by a lagoon channel which may be as much as 100 miles wide. The depth of the channel is often 75 or 100 feet and may in exceptional cases be as great as 180 feet.

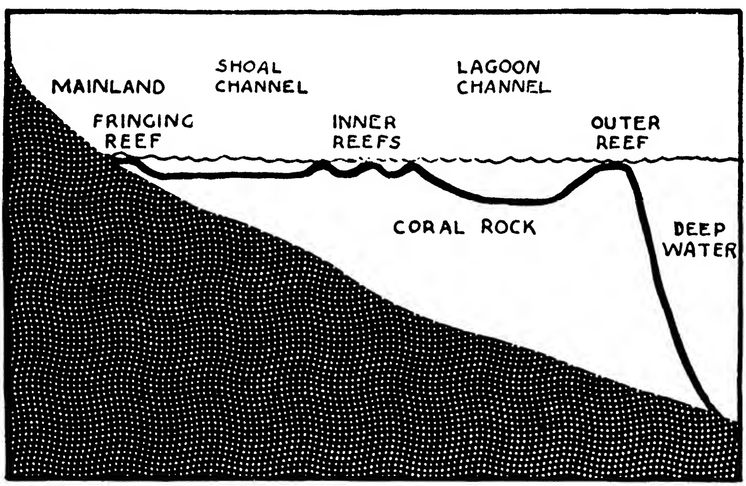

Figure 3. Sections of a barrier reef. After Jukes. Not to scale.

The outer edge of the reef slopes rapidly so that the depth at a few miles beyond it may reach 5,000 feet or more. The barrier reefs are not always continuous but form more or less broken series of roughly parallel

ramparts which may be divided into an outer and an inner series (see figure 3). The latter encroaches more or less into the lagoon channel. Each reef has for its outer edge an enormous mass of coral growing just below the surface and forming huge boulders and pinnacles (Figure 4). These reach out under the breakers and form to seaward a steep rough cliff which merges below the zone of active growth into a slope of dead coral rock, known as the talus slope. Behind the outer edge, the crevices and gullies between the coral become filled with coral fragments broken off by storm waves and thrown into quieter water. Still further to the lee of the reef the interstices of rock become filled with sand, small growing corals and coralline algae and the rock becomes cemented into a crude pavement or platform. This pavement is bordered to the leeward by

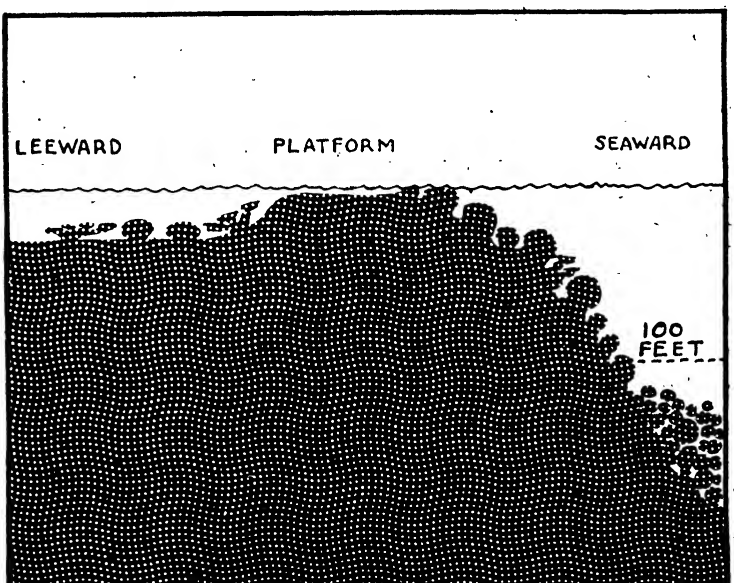

Figure 4. Section of the outer edge of a reef. Not to scale.

the lagoon channel, which is dotted with scattered heads of coral. These heads are more scarce towards land, where the effects of fresh water drainage and sediment become more pronounced. The more exposed parts of the mainland and of islands within the lagoon channel may acquire fringing reefs. Small islands may appear on the reef itself where they are gradually formed by the accumulation of dead coral and silt and where finally, as sand accumulates, palm trees and mangroves may develop from seeds washed ashore.

The foregoing brief and simplified description of the Great Barrier Reef applies in a general way to all barrier reefs. These are found in the Pacific among the Society Islands, the Fiji Islands, New Caledonia and to the southeast of New Guinea, but are unusual in the Atlantic Ocean and only appear to a limited extent in the Indian Ocean.

Atolls are in some ways the most interesting of reef formations. They are the true coral islands of romantic fiction as well as of scientific texts. Far from any mainland they are like oases on the surface of the ocean, arising as if by magic in water thousands of feet deep. Graceful palm trees grow on the fringe of the quiet waters of their protected lagoons where an abundant supply of seafood awaits the hungry castaway. Atolls are no less intriguing to the scientist since they offer a diversity of interesting problems, in their structure and mode of formation. The coral reef of an atoll is essentially the same as a barrier reef or fringing reef, but differs in being roughly ring-shaped, with steep outer sides sloping down into very deep water. Inside the encircling ring of reefs is a shallow lagoon which is rarely 100 feet deep (see figures 5 and 6). The lee-

ward sides of the reefs lining the lagoon are built up into a series of sand banks and small islets which together form a ring shaped island interrupted by gaps which give access from the lagoon to the ocean. These islands may possess a certain amount of soil and be covered with vegetation, particularly coconut palms, the large seeds or nuts of which are able to drift thousands of miles across the ocean before being cast ashore.

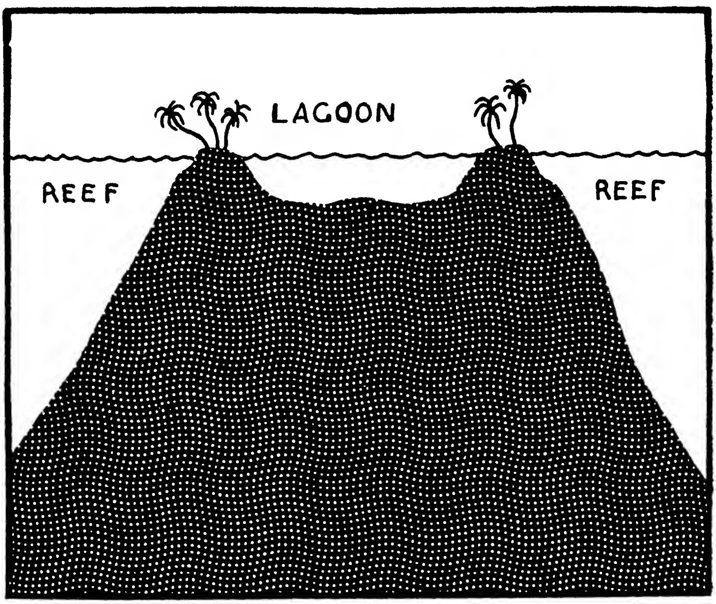

Figure 5. Section of an atoll. Not to scale.

One of the most typical of these formations is the Cocos-Keeling Atoll which lies in the open ocean surrounded by water more than 6,000 feet deep at a distance of less than six miles from the shore. Moreover it is situated in a part of the ocean which is more than 500 miles from the nearest land. It was first studied by Charles Darwin when he visited it on board H.M.S.

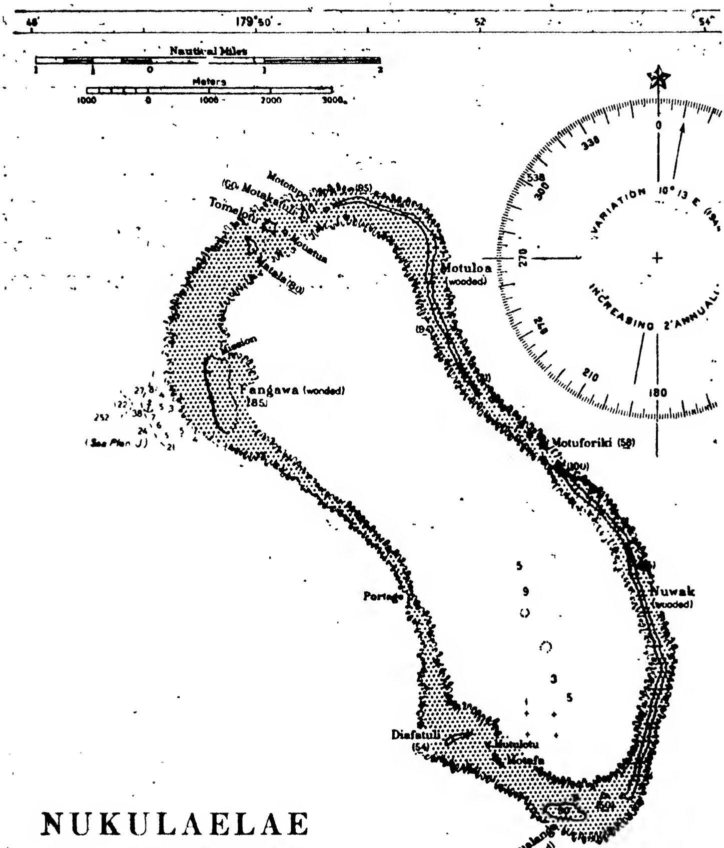

Figure 6. Chart of Nukulaelae, an atoll in the Ellice Island group, South Pacific. From H. O. 1981.

Beagle in 1836 and subsequently has been visited by many scientists interested in coral formations. Among these mention should be made of Wood Jones who, in his book, "Corals and Atolls," describes the influence of winds and currents in moulding its shape.

In early times the coral rock was looked upon as a kind of plant and it was not until 1753 that Peysonell, who made a particular study of the Western Atlantic

reefs, was able to establish conclusively that it is, in fact, a form of animal life. Once this fact was accepted, scientists who followed the early navigators to the tropical seas began to take a great interest in the manner whereby such creatures were able to build atolls, barrier reefs and fringing reefs. The great difficulty was to explain the appearance of atolls in the middle of deep oceans. At one time it was thought that corals grew at the bottoms of the deep tropical seas, and that succeeding generations of them, growing upon the accumulated dead limestone skeletons of their ancestors, would in the course of millions of years reach the surface. Such ideas however, were soon dispelled by the dredging operations carried out by naturalists, whereby specimens of sea life are dragged up from the bottom. The result of these early studies showed quite clearly that reef corals are unable to grow except in relatively shallow water. Darwin, in his celebrated book, "The Structure and Distribution of Coral Reefs," made it plain that reef corals grow vigorously in water less than 100 feet deep and that they are unable to live at all below about 150 feet. Thus any theory of the origin of coral reefs must, first of all, account for the existence of a platform upon which the coral may grow, situated at a distance below the surface of less than about 150 feet. The reasons for the inability of corals to grow below this depth are briefly discussed in Section 1 of this handbook.

It will be seen immediately that no particular problem attaches to fringing reefs, since these are always close to land, which acts as a suitable platform where it extends below the surface. In order to account for barrier reefs, up to 100 miles from land, or for atolls,

sometimes thousands of miles from land and surrounded by very deep water, the earlier naturalists assumed that ring-shaped atolls grew from the edges of extinct volcanoes lying close beneath the surface of the ocean. This, however, does not explain barrier reefs and it would require something beyond mere coincidence to account for the existence of the innumerable atolls which are scattered about the tropical Pacific and Indian Oceans.

Darwin produced, as a result of careful study, a theory which fits all the known facts to a remarkable degree and accounts for the presence not only of atolls but also of barrier reefs. This theory is in the main still held today but a number of later writers have added to it on the basis of new information which has come to light. According to Darwin, all the coral reefs then known were situated in areas where, at some time in the past, a sinking of the earth had taken place. This subsidence theory explains the formation of the three types of reef with admirable simplicity.

The first stage in the formation of an atoll or a barrier reef was thought by Darwin to be a fringing reef. A reef of this type might be expected to grow on the shore of any continent or island in tropical seas where other conditions were suitable. As the land began slowly to subside the reef would continue to grow upwards and, unless the subsidence were too rapid, the growth of coral would keep pace with it. The continual sinking of the land would increase the distance between the reef and the shore so that a deep wide channel would develop and the reef would now have all the characteristics of a barrier reef (see Fig. 7). If the land happened to be a small island, it would eventually disappear be-

low the surface and the barrier reef would now be an atoll, by continuation of its upward growth.

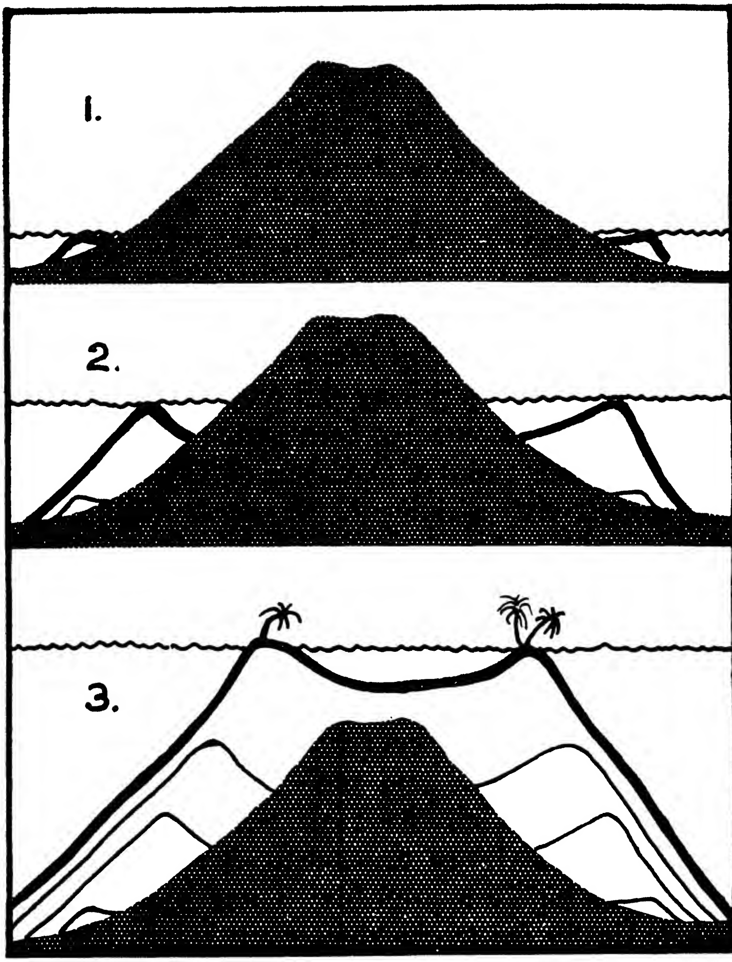

Figure 7. Sections illustrating the formation of barrier reefs and atolls according to Darwin's theory. 1, 2, 3, successive stages in the sinking of land beneath the water. 1, Fringing reef. 2, Barrier. 3, Atoll.

Geologic evidence to support this theory was discovered in the general appearance and topography of many of the islands with barrier reefs by the American

scientist, J. D. Dana, but others found gaps in the Darwinian theory and rival theories were advanced. None of these have supplanted that of Darwin, but each has added something to the general understanding of reef formation.

One of the two principal objections to the universal application of the subsidence theory was based on the fact that fringing reefs were found in the same general area as barrier reefs. Since on this theory fringing reefs may only continue existence on a stationary coast and barrier reefs may only form on a subsiding coast, the areas in question would of necessity be in the paradoxical situation of both sinking and remaining stationary. This objection, however has been partially answered by the recent observations of Davis and of his predecessors, who suggest that a tilting of the earth might occur, which would bring about sinking in one place and rising in another close by.

The subsidence theory would lead one to expect that as a result of sinking of the earth, atolls should exist with lagoons considerably deeper than the 180 feet, which is the maximum actually observed. Furthermore the widespread and prolonged sinking of the earth's surface in all the coral seas simultaneously, which Darwin's theory demanded was considered by many to be highly improbable. These and other objections finally led to the theory put forward by Sir John Murray, one of the great scientists who took part in the celebrated four year expedition of H.M.S. Challenger, which began in 1872.

Murray concluded that the platforms on which reefs are built originate as submarine ridges, probably of volcanic origin. These would not necessarily come

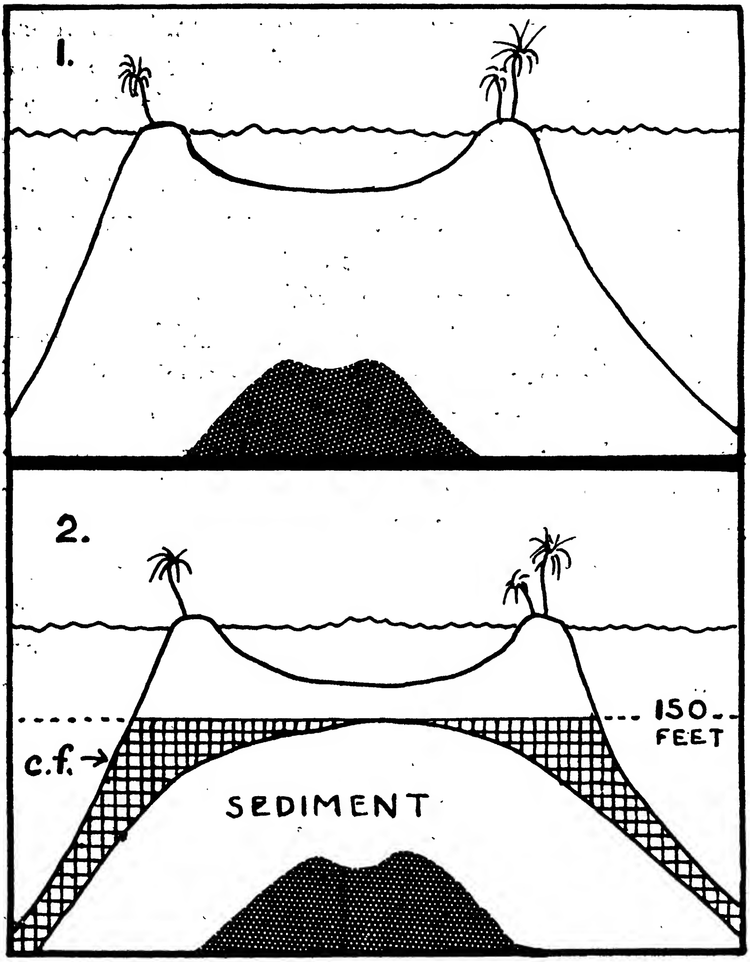

Figure 8. Sections of an atoll for comparison of the subsidence theory with the submarine bank theory of origin. 1, section according to the subsidence theory. 2, section according to the submarine bank theory. (c.f.) Cross hatching represents fragments of broken coral which have rolled down the slope and accumulated as the atoll grew.

close enough to the surface for corals to begin their growth but they would become shallower as the result of an accumulation of fine limestone silt formed by the skeletons of foraminifera and other microscopic ani-

mals which are always present in the ocean in countless millions and which are continually falling to the bottom. This is not so improbable as at first sight might appear, since it is well known that large areas of chalky rock now part of land were originally formed by similar deposits on the ocean floor. Murray's theory was that the silt would accumulate upon the submarine ridges or mounds until they reached within 100 feet or so of the surface, where active coral growth could take place. Since coral grows more rapidly on the outside of a reef and tends to die as a result of sediment in the more sheltered inner portions, this would account for the innumerable ring-shaped atolls, without the need for assuming widespread sinking of the earth's crust.

Further suggestions advanced include the theory that non-reef building corals, which are able to live in deep water, were responsible for building up the platforms. Others are based upon a belief that islands might be cut down by wave action and water currents to form the base upon which the reefs have grown. The most important contribution to the subject, however, is the Glacial Control Theory advanced by R. A. Daly.

According to Professor Daly, all existent coral reefs have been formed since the last glacial epoch. During the period of glaciation the poles were covered by ice caps several thousand feet thick and extending considerably below the polar circles into what are now the temperate latitudes. The result of trapping such great quantities of water at the poles was that the general level of the ocean was lowered by about 175 feet and all previously formed coral reefs were killed by cold. The former ocean bottom, exposed by the withdrawal of water, and no longer protected by reefs was cut back

by wave action so that broad platforms were formed around the land (Fig. 9). When the ice age passed, the sea level rose to its normal position and engulfed the platforms. As it became warmer, the present day reef began to grow upon these new bases, which were all at a depth of under 175 feet and therefore suitable for coral growth.

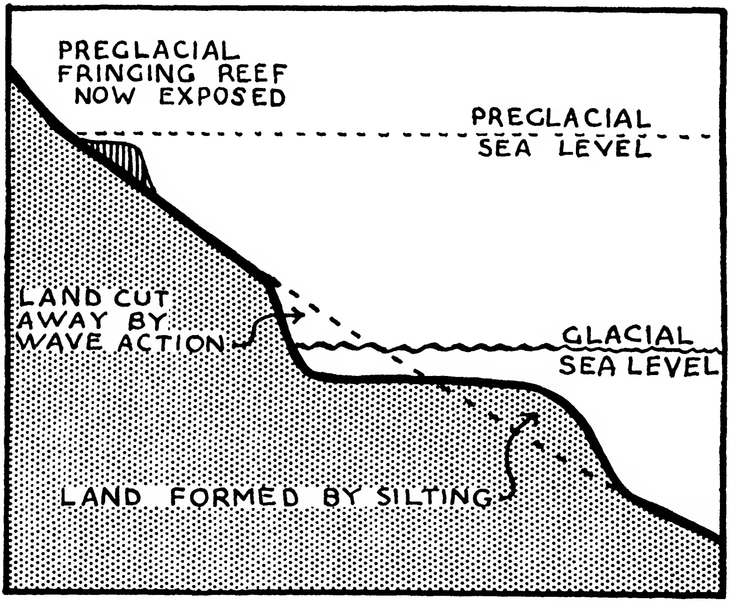

Figure 9. Section illustrating the formation of a platform by wave action in the marginal seas, during glaciation.

In general it may be said that Darwin's theory of land subsidence, combined with Daly's glacial control theory, is adequate to explain most known reefs but that there are also undoubted cases where the platforms have been formed by agencies of a different nature such as those provided by other theories. Final proof is very difficult to obtain and even deep borings made

into the underlying rock of atolls have not provided satisfactory answers. The celebrated expeditions to Funafuti Atoll, to the north of the Fiji Islands, resulted in the sinking of a bore to a depth of over 1,000 feet. According to the Darwinian theory it might be expected that the core from such a boring would consist of dead coral entirely, formed by upwards growth as the underlying land mass continued to sink (see Fig. 8). The theories of submarine ridges and accumulated sediments would, on the contrary, lead one to expect a core of silt at a depth of less than 175 feet, below which coral does not grow, and below this the ancient rocks of the submarine ridge. When the actual core was examined, it was found to consist of coral fragments only, thus supporting Darwin's theory. Objections to this were raised, however, on the grounds that the bore might well have traversed the outer edge or talus slope of the atoll, and so missed the sedimentary and volcanic rock. Although this left the question open, further borings have been made recently. The results are not known in detail at the time of writing, and further discussion would be beyond the scope of the present brief introduction to the fascinating problem.

It is not the purpose of this handbook to enter into a detailed appraisal of the various theories. Those who would care to know more of the fascinating problem of coral reef origin and the facts upon which the theories are based should consult, "The Coral Reef Problem," by W. M. Davis. This provides the best and most exhaustive of modern accounts. It is of a technical nature however, written from the geologist's viewpoint, and the general reader may prefer to read the first chapter of C. M. Yonge's book, "A Year on the Great

Barrier Reef," which contains an excellent account of the general subject as well as a detailed description of the Great Barrier Reef, written in non-technical language.

3. WESTERN ATLANTIC REEFS

CORAL REEFS in the Western Atlantic have in most cases been built under conditions somewhat different from the majority of those discussed previously. A great part of this area lies within what Davis (1928) has called the marginal belt. The characteristics of such an area are related to conditions which are supposed to have existed there during the glacial periods. While the true coral seas did not become too cold for the continued life and growth of corals, there were certain areas between them and the cold seas in which the reef corals died during glaciation. These are known as the marginal seas. During glaciation the seas dropped and the land emerged from the water. In the true coral seas new reefs grew and protected the land from abrasion. In the marginal belt, however, no reefs existed during glaciation and the shore remained unprotected during that period. As a result the waves were able to wear away the coast and form a platform around it, just below the sea level. Part of this platform was due to the sea cutting into the land and part due to the debris thus formed settling down further out from shore (see Fig. 9).

Towards the end of the glacial period, when the seas once more became warm, reef corals were again able to live and reefs were formed upon these platforms. Such reefs are called bank reefs and are characterized by being further from shore than a fringing reef but at the same time possessing a shallower lagoon channel than a barrier reef. Moreover the reef is often at some

distance inside the seaward edge of the platform and does not grow on the edge of deep water in the way that true atolls and barriers do.

Such conditions were present in the marginal seas of the Atlantic. These stretch from the Parcel das Paredes reefs of middle Brazil, by way of Cape San Roque to the north, along the lesser Antilles and, finally, to the Florida Keys and Bermuda. In most cases earlier reefs were present up to 50 million years ago, long before the glacial period, in the warmer seas of what geologists call Tertiary times. A great part of the platforms upon which the present day reefs grow was formed by wearing down of this old coral formation.

Bermuda has a most interesting history. Briefly, during the geologic age known as the Eocene, between 40 and 50 million years ago, it was a volcano which later subsided below the surface of the ocean and was worn down by wave action. It sank further and at the same time became covered with marine sediments of a limestone character in the later Tertiary period. There is some evidence that an atoll grew on the bank during this period. Subsequently, however, the mass was exposed once more, well above the water level, and formed an island of about 230 square miles, according to Davis. This may have been due to a drop in ocean level of between 100 and 150 feet which resulted from the withdrawal of water to the ice caps during glaciation.

While exposed above the ocean surface during glacial time the land was worn by wind action and much of the present rock surface is formed from windblown limestone. Further wear due to wave action and a submarine accumulation of debris formed a platform.

When the sea again rose and became warmer this provided the base upon which the present reefs have grown. The reefs are comparatively weak, and probably able to exist only by virtue of the influence of the warm Gulf Stream water.

Florida possesses bank reefs which, like these of Bermuda, rarely reach the surface. They are built upon a broad shallow platform. This was originally, 50 million years ago, at the bottom of an extensive shallow sea which covered the southern portion of the Southeastern United States. It was then raised above the surface and worn by wind and rain action. Subsequently the eroded land surface was again submerged and remained so during what is known as the Tertiary period. A number of reefs were formed over a considerable part of the area at this stage.

At a much later time, within the last million years, the land was intermittently exposed and flooded as a result of the withdrawal of water during glacial periods, and its release during interglacial times. The Pleistocene reefs which were formed during this series of changes formed rock 100 feet thick. At the time of the last glacial epoch, while the sea level was low a platform was cut into the land. As the ice caps finally melted the platform was once more flooded and today it forms the base upon which grow the coral reefs off the Florida Keys. As a result of independent earth movements, however, a portion of the old Pleistocene reefs still remains above water to form the line of keys extending from Miami to Key West and Dry Tortugas.

The present day reefs have grown a mile or two offshore from the Keys. Between the reefs and the Keys a process of chemical and mechanical sedimentation is

slowly tending to fill in the channel, where small patches of reef heads are formed. The living reefs do not extend north of Fowey Rocks, not only because of the drop in temperature as one travels north, but mainly, it has been suggested, because of a southward drift of siliceous sands which kill or restrict coral growth by silting action.

The Marquesas and Tortugas reefs, which have been called atolls are not properly so, but are ring-shaped reefs built on shoals of sediment on the shallow banks. They are not associated directly with subsidence, nor are they fringed by deep water, in the way true atolls are.

To the west of Florida the shallow muddy bottoms do not offer a foothold for corals. Nevertheless recent diving expeditions carried out by biologists of the Marine Laboratory have shown the presence of a considerable reef coral growth in depths of from 50 to 150 feet, in the Gulf of Mexico, west of Tarpon Springs, Florida.

The Florida reefs are best studied some miles south of Miami and are easily examined through a glass bottomed bucket from a small boat in fair weather. Many of the smaller coral species may be found close inshore by those willing to wade a short distance at numerous places in the Florida Keys. Some are found as far north as the shores of Elliot Key or on the bars south of Biscayne Key. In small patches, reef corals are to be found considerably north of Miami, but only offshore and in relatively deep water.

Bahamas. The same general process that underlies the origin of the Florida reefs is probably true of the Bahamas. The living reefs, however, are much better

developed and those to the east of the islands of Abaco, Eleuthera and Andros are very extensive. The reefs which protect the northern shore of New Providence, to the east and west of Nassau are particularly well situated for inspection by the visitor with little time to spare, owing to their protected position, and may be visited by small boats in good weather.

Much of the present land of the Bahamas was accumulated in the form of chemical deposits in the lagoons of preglacial atolls and the platforms on which the present reefs stand were formed during a glacial period when the land was over 250 feet above the present sea level. In some respects the Bahamas area like Cuba and Jamaica is closer to the coral seas type and there are several true atolls, notably Hogsty reef, to the east of Cuba, and the drowned atoll of Cay Sal Bank, lying between Cuba and the Florida Keys.

Cuba. Off the north coast of Cuba are the Colorados reefs which are barrier reefs, more closely allied to reefs of the true coral seas. They lie up to 20 miles offshore and extend from Cape San Antonio to Bahia Honda. Other reefs on the north coast extend from east of Havana to Nuevitas Bay. There are scattered reefs only at the eastern end of the island.

The southern reef is more nearly similar to the Florida reefs. It grows at some distance back from the edge of the shelf and is not a barrier reef of the true coral seas type. This formation is best developed east and west of the Isle of Pines where it guards the Gulf of Batabano, and also between Trinidad and Cape Cruz. Together these are the longest reefs in the West Indies.

The West Indies generally conform to the foregoing

descriptions with variation in detail only. The reef structure of Barbados alone has never been satisfactorily explained. It appears however, that at some time in the past the island was submerged and a layer of limestone was deposited. During subsequent periods this was added to by the growth of a series of fringing reefs which were formed at various times, while the relative levels of land and water were changing, so that they formed a series of terraces. Many of these old reefs are now elevated above sea-level.

Reef formations are present to a limited extent off the coast of Mexico on the Campeche Bank, where they form the Alacran reef; and near Vera Cruz. Apart from these the Gulf of Mexico has no significant reef formations.

The British Honduras reefs are well developed. They extend almost continuously for over 125 miles, which is the longest continuous formation in the West Indies. Both bank and barrier reefs are found here.

An imperfect atoll occurs at Los Roques, 70 miles north of the coast of Venezuela, and reefs are also present to a limited extent off the shores of Jamaica.

The Lesser Antilles all possess living reefs of the marginal sea type which are now elevated above sea level and have grown upon platforms formed by the abrasion of wave action during the glacial period. For further detailed descriptions of these and of the other Atlantic Reefs reference should be made to the excellent account of Vaughan (1919). A more recent and exhaustive discussion of the formation of reefs throughout the world is to be found in the magnificent work of Davis (1928), in which the theory of the marginal seas is thoroughly expounded.

4. STRUCTURE AND HABITS OF THE LIVING CORAL

THE BEAUTIFUL white stony ornaments which are sold in curio shops bear little resemblance to the living green, gold or orange corals. In fact they are merely the bleached skeletons of their former selves. The creature which forms the skeleton is an animal very low in the scale of evolution and is very similar in general structure to a sea anemone.

A sea anemone grows attached to rocks and consists essentially of a soft tubular body with an opening at one end, which is its mouth, surrounded by a ring of hollow tentacles. Within the opening of the mouth the skin projects inwards to form a passage or throat known as the stomodoeum.

The coral in its simplest form is the skeleton of a simple anemone-like creature known as a polyp. The skin covering the lower part of the polyp has the peculiar capacity of forming on its surface a stony layer, much as the skin of an oyster forms a shell outside it and enclosing it. Since the polyp is tubular the stony layer takes the shape of a limestone cup. A short pillar-like fold of skin in the center of the base forms a vertical axial rod called the columella.

The coral polyp is complicated by vertical folds of the wall of the tube. There are two types of folds. One of these consists of an infolding of the entire body wall. The folds project radially part way into the interior of the cylindrical polyp. The skin turned inside by the

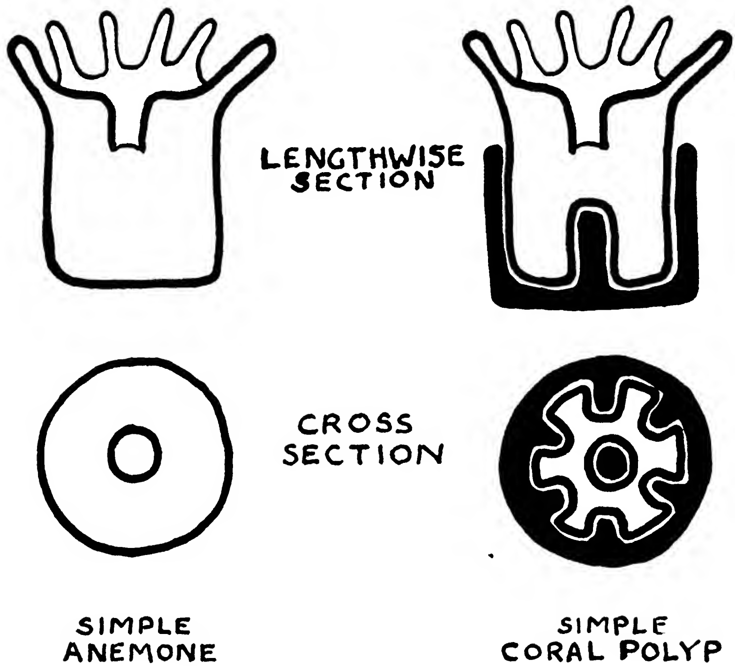

Figure 10. Lengthwise and cross sections of a simple anemone and a simple coral. The mesenteric folds of the body wall which project into the interior are omitted for the sake of clarity. Dark portion represents stony skeleton.

folds was originally part of the outside of the polyp and it continues to secrete the limestone deposit. In this way it forms radial stony partitions projecting from the wall of the coral cup inwards towards the columella. In some corals there is little development beyond this stage, and the polyp merely forms a single cup with radiating plates or septa inside it. Most corals, however, develop by growth in size and complexity of the individual polyp or by the branching and multiplication of polyps.

The polyp may enlarge and grow out sideways into lobes, without dividing or branching, so that it eventually becomes flower shaped. Since the coral cup grows with the polyp this too will become flower shaped

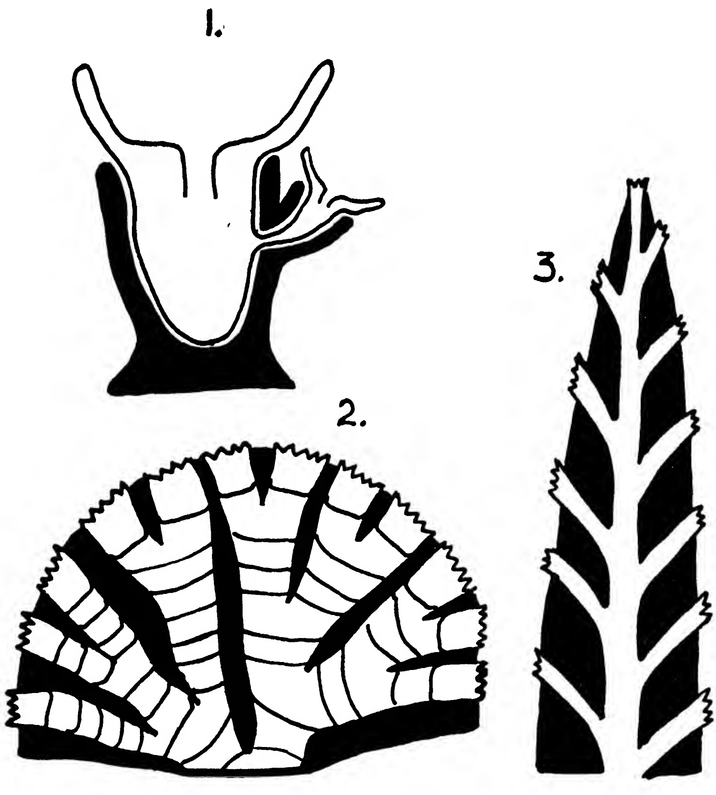

Figure 11. Lengthwise sections of corals illustrating modes of branching and colony formation. Greatly simplified. 1, lateral budding of a single polyp . 2, formation of a massive colony by growth and branching of the polyps, showing transverse partitions laid down as growth of the polyp progresses. 3, growth in which the original polyp continues to remain at the apex, forming branching colonies similar to Acropora. Dark portion represents stony skeleton.

(Plate 20), or where considerable outgrowth takes place it may eventually become convoluted as in the brain-corals (Plate 14).

In most corals, as the individual polyp continues to grow, its cup becomes longer and more tubular. At the same time the polyp branches to form daughter polyps and the original cup now becomes two. As the process continues the older part of the tube is cut off by transverse partitions and a chambered mass of limestone rock is developed (Figure 11). When the polyps are only loosely connected a branched structure results (Plates 22, 41).

In other cases the polyps may remain close together and the cups become united into a compact mass. (Figures 11, 12 and Plate 25) Sometimes the coral mass itself is branched, with small cups projecting over the entire surface as they bud off from the main polyp (Plate 2).

Thus, in various ways, the small anemone-like polyp eventually forms large masses of rock of considerable weight, with the overall production running into billions of tons each year. The stony rocks developed by the polyps vary greatly in appearance from small, delicate cups to treelike branching colonies or enormous boulders.

In addition to the folds of skin which form the septa or radial plates, the coral polyp possesses another type of internal fold. The second type, known as a mesentery, is an infolding of the inner lining only. For the sake of simplicity they have been omitted from the previous diagrams.

During the breeding season the eggs and spermatozoa begin to develop in the swollen edges of the mesentery.

When they are ripe, the spermatozoa of one polyp are released through the mouth and are carried by water currents until they eventually reach another polyp. Here they are drawn into the mouth by the water currents which are set up to bring food into the coral animal. In this manner they reach the inside of another polyp and fertilize the eggs while they are still attached to the mesentery.

After a short period of development the eggs are set free and leave through the mouth of the parent. At this stage they are in the form of small pear shaped bodies about the size of a pinhead. Small rapidly beating hairs or cilia clothe the surface of the coral larvae and give them a limited swimming ability. The stage at which the larva is drifting or swimming feebly in the water may last from one to three weeks. During this time it may be carried considerable distances by ocean currents and wind drifts, thus accounting for the presence of living corals on such isolated reefs as those of Bermuda and many of the lonely Pacific islands. Within a week or so, if the larva reaches a suitably hard surface it attaches by means of a cementing substance formed at one end and grows into a small tube. The upper end is indented to form a fleshy cup which later becomes the mouth. Tentacles grow out from the rim of the upper surface and the skin immediately begins to form the stony skeleton of the first polyp of a new colony.

The tentacles are withdrawn during the daytime, but at night they are expanded for the purpose of catching food. This consists of small animals, principally crustacea, although some of the larger polyps, such as *Manicina areolata* have been observed to eat very small fish.

Each tentacle possesses large numbers of stinging cells

or nematocysts. These are able to shoot out microscopic poison darts which paralyse the prey. The tentacles then turn towards the mouth and the food is passed inside. In some cases feeding is helped by the beating of small hairs or cilia which cover the upper surface of the polyp. The food is rapidly digested by juices formed by the mesenteries.

All reef-building corals contain within their tissues a large number of very small single-celled plants known as Algae. Since plants take in carbon dioxide from their surroundings and give off oxygen the coral benefits by their presence by obtaining a supply of oxygen in its tissues for breathing. In the same manner the Algae are able to use the carbon dioxide which is given off continually in the breathing of all animal tissues. The waste products of the coral are also useful to the Algae. Thus the strange association of a plant living inside an animal is mutually beneficial.

The rate at which corals grow has been the subject of a considerable amount of experiment. Results obtained by Vaughan show that on the Florida and Bahamas reef the increase in diameter varies from about one half inch to nearly two inches per year. In twenty-three years a brain coral measured in the Pacific by Dr. Mayor had grown from thirty inches to seventy-six inches. It is easy to appreciate, in the light of these figures, that corals may, over a period of years, grow into dangerous obstructions in channels once considered safe and that they have built up considerable masses of land during the long period of geological history.

5. ASSOCIATES OF THE LIVING CORAL

CORALS ARE NOT the only reef builders or inhabitants of coral reefs. There are an amazing variety of other living creatures associated with them, some of which build up the limestone formation while others are active in tearing it down.

Living in the coral rock itself are found various burrowing or boring animals, which may so riddle it with holes and passages that the rock may break apart. Certain encrusting sponges, yellow, lavender, purple or red in color are found on the surface of the rock or of sea shells and one of these, *Cliona,* eats its way into it through small processes. Other sponges with great variety in shape and color are attached to the surface of coral rock.

Certain strange worm-like creatures, the gephyrids, form burrows and are only seen when the coral is broken apart.

The spiny sea urchins or sea eggs, spherical or ovoid in shape and covered with spines, possess chisel-like teeth which enable them to eat pockets out of the rock. Among these is the long black spined sea urchin, *Centrechinus antillarum.* A smaller species, more ovoid in shape, with shorter purple spines is *Echinometra lucunter.* Still another sea urchin has fewer spines which are short and thick so that it is appropriately called the club spined urchin, *Eucidaris tribuloides.*

Some of the sea shells have adopted a burrowing form of life, including *Pholas, Gastrochaena* and *Lithophaga.* Associated with the coral by attachment, but

not forming extensive burrows are numerous others, such as the wing shells, *Pteriu* and *Pinctada,* the ark shells, *Arca* and *Barbatia,* the date mussel, *Modiolus,* and the scallop shells, *Pecten* and *Lima*. The jewel box shell, *Chama,* and the so called reef oyster, *Spondylus* are well known to collectors. The strange oyster *Ostrea frons* with hook-like outgrowths from the shell whereby it attaches itself, is often found on corals or seafans. Trapped in the rock by growth of the living coral around them are also found *Lima* and *Pteria.*

Some of the sea worms similar to those commonly used for bait are able to bore through the living rock by means of powerful jaws. One of these, *Eunice fucata,* has the peculiar habit of breaking off the hindmost part of the body in which the eggs develop. This portion leaves the burrow and swims to the surface of the water, where the eggs are released by breakdown of the body enclosing them. This happens at a certain phase of the moon during midsummer, in the early morning and the careful observer may see the surface of the ocean above the reef literally alive with wriggling worms. In the Pacific islands where a similar phenomenon takes place, the Palolo worms, as they are called, are highly esteemed as food.

Some worms do not destroy the rock but use their burrows for protection. They are lined with a hard porcelain like material and the head of the living worm, which projects into the surrounding water when undisturbed looks like a beautifully colored flower. A slight movement or shadow, however, will cause retraction into the burrow so quickly that the movement is undetectable.

Sea anemones and seasquirts are frequently assoc-

iated with corals and the rock is often encrusted with brightly colored growths of seamats or Bryozoa. Certain barnacles, *Creusia* and *Pyrgoma* become attached and as the coral grows around them they may become entrapped so that they appear as gall-like swellings on the rock surface, each with a small slit through which the appendages of the barnacle project in search of food. In a somewhat similar manner the gall crabs, *Hapalocarcinus* and *Cryptochirus* become entombed in the living coral.

Superficially similar to the coral but really not too closely related is the stinging coral, which grows into small branches like miniature stagshorn or may form encrustations on the surface of old coral or dead seawhips. The polyps are very small so that the skeleton is easily distinguished from true coral by the lack of visible cups. In their place the surface is covered by fine barely visible holes, which account for the scientific name, Millepora. The stinging cells of the false coral are sufficiently powerful to develop an irritating rash when handled with the bare fingers.

A distinct contribution to the material of reef limestone is made by the so called soft corals, often referred to as seafans or seawhips. These brightly colored organisms are related to corals, although they differ in many respects. The common seawhips, known as *Pterogorgia acerosa* consist of long whip like branches the surface of which is covered with small barely visible polyps. The axis of each branch is a horny skeleton. Embedded in the flesh surrounding it are numerous small limestone spicules, which add to the coral sand when the whip dies. Much thicker and heavier than the seawhip, forming finger like branches or even thick

encrustations is the beautiful purple *Briareum asbestinum*. The numerous fair sized polyps form a thick fur on the living seafinger.

Seafans, as their name indicates, grow in the shape of large blue, purple or yellow leaf like expanses. The basic structure is similar to that of seawhips, but the numerous short branches are interlaced and fused together so as to form a close network. The common seafan in the West Indies is *Rhipidigorgia flabellum.*

Among the crevices between hard corals, around the bases of soft corals, and in the burrows formed by other animals, a varied collection of crustacea is found. The small bright green shrimp-like *Gonodactylus* is frequently to be seen here. There are also snapping shrimps little more than an inch or so long but capable of making very loud clicking noises as they snap shut the giant claws which are asymmetrically developed on the leg of one side. The female may be carrying bright orange egg masses. In addition there are masked crabs, with their bodies camouflaged by the algae, hydroids or other small sea growths that are attached to their back. In the open or in the larger crevices are spider crabs, large mantis shrimps, *Squilla empusa,* the edible spiny lobster or crayfish, *Panulirus argus,* and the larger crabs. In crevices of the rocks or in burrows in the sand are occasionally found the edible stone crab, *Menippe* or the weird looking, shovel nosed, Spanish Lobster, *Scyllarides equinoctialis.* Occasionally among rocks the octopus may also be encountered.

Enormous loggerhead sponges *(Spheciospongia vesparia)*, the large cup sponge, sometimes larger than a small barrel, the black commercial wool, reef and grass sponges and other brilliantly colored sponges, tubular,

spherical, encrusting or branching grow on the bottom in less close association with the coral. The microscopic silica spicules contained in the tissues of many of these eventually are released by death and contribute to the building of the reef rock.

Living independently of the coral are also the small red starfish *Echinaster sentus*, the six armed starfish, *Linckia guildingii* and the giant starfish *Oreaster recticulata*. These possess limestone skeletons. The dark colored, leathery skinned sea cucumber, *Holothuria floridana* moves like a giant slug over the bottom and extracts nutrient by running the sand through its body. If interfered with it may eject its entire set of internal organs and crawl away to grow them anew. Some of its relatives have very delicate transparent skin and may live in the interstices of the rocks. *Euapta lappa*, one of these, may be crammed full of coarse sand but yet is so delicate that it falls apart on handling.

Close relatives of the sea urchins are the potato urchin, *Clypeaster rosaceus*, which lives among weeds or burrows in the sand. Greatly flattened versions of these are the sand dollars, which are also found in the sand between masses of coral.

Many of the coral reef animals which are not closely associated with the coral itself, live among the so called sea grasses which grow in the quieter shallower waters behind the outer reef. These grasses are not seaweeds but are really flowering plants which have become adapted to life under the ocean. Commonest is the flat bladed turtle grass, *Thallassia*.

Certain marine algae or seaweeds living on the reef and in the shallow lagoons have the property of depositing limestone in their living tissues so that they also

add to the sand and rock of coral reefs. A common variety is *Halimeda*, bright green in color with branches that have the appearance of flat triangular beads strung together. Sometimes this occurs in very large clumps, particularly in shallow water near the shore. Other kinds of limestone seaweed or coralline algae are known as nullipores. They form heavy encrustations and, in the Pacific at least, are important factors in building up the reef. On the western Atlantic reefs they are much less conspicuous. A common form of calcareous alga here is *Lithothamnion*, which grows in delicate branching form in various colors.

The species of conchs, whelks, cowries, cone shells, olive shells, tulip shells, limpets and other seasnails which inhabit the reef are so numerous as to require an entire book to themselves. The same thing is true of the bivalve shells, such as the oysters and their relatives, the scallop shells, clams, wing shells, chamas, cockles, and mussels. Although space does not permit of a description of these, the bibliography at the end of this book contains selected references to handbooks specially written for their identification.

Fishes associated with the coral reefs are so numerous that they are numbered by the hundreds of species and may only be briefly mentioned here. A common characteristic of those which make their homes among the coral boulders is the amazing brilliancy of color and design. Foremost in point of brilliancy of color are the angel fish, queen trigger fish, demoiselles and parrot fish. Groupers and giant jewfish live among the rocks, where the vicious moray eel waits for its prey. Sharks and barracudas are always found although they range over a variety of places other than the reef in search of food.

Among the larger associates of coral reefs are the loggerhead, hawksbill and green turtles, which move to the sandy beaches to lay their eggs. Between the reef and the land, on grassy or sand bottoms the sting rays and leopard rays are common and much more rarely the giant manta ray or devilfish is seen.

Thus, not only the coral, but a complex community of animals living together really comprise the living reef. Some break down the rock and some build it up, but all contribute in some form or other to the rock, sand, mud and detritus. Crevices between the smaller particles are filled in with dead limestone skeletons of the microscopic foraminifera and other tiny creatures which drift suspended in the seawater during their short lives and which add to the bottom deposits when they die. When the mass of rock and sand is raised above the surface the rain dissolves lime from the surface and redeposits it as a cement below. In this manner the smaller grains and larger boulders were fused together to form the solid coral rock which is now underlying the soil of the Florida Keys and certain other parts of the Atlantic coral area, where the earth movements mentioned in Chapter 3 have raised the older reefs above sea level.

6. COLLECTION AND PREPARATION OF CORALS

WHILE THE collection of coral specimens from the outer reef involves the use of a boat and necessitates diving, a great number of coral species may be collected by simply wading in shallow water in appropriate localities. A glass bottomed bucket is a useful aid in finding specimens, particularly when there is sufficient wind to make the water choppy. Most of the corals found in shallow water are loose or only lightly attached to the underlying rock. The larger reef corals are firmly cemented to the bottom and a tire lever or crowbar is required to break them off, or to pry loose portions small enough to handle. Some of these are found in quite shallow water but the majority occur in the deeper water of the outer reef. While some of them, particularly the branching forms may be broken loose with a strong, multiple pronged grapnel the most satisfactory method is to dive to the bottom and collect the specimens by hand. An open diving helmet of the simplest type will suffice, and even this may be dispensed with by a good swimmer, equipped with one of the face masks now obtainable in sporting goods stores at most seaside cities.

From what has been said in Chapter 1 it will be realized that corals are very sensitive to their surroundings. Some species are more sensitive than others and are virtually restricted to a definite type of locality. Others, more hardy, are found over a wider range of

situation. Moreover, even in a single species, the form and appearance of the coral may vary very greatly depending upon the nature of the surroundings. In rough water there is a tendency towards more massive or encrusting growth or to the development of short thick branches in branching forms. Where the water is quieter conditions are more conducive to diffuse branching or to thin projecting plates. In deeper water, below the region of greatest wave action, the spindle shaped or pillar like form is encouraged.

As an example, the finger coral, *Porites porites,* is more openly branched with more slender branches in shallow relatively quiet water. On the reef itself, where wave action is more vigorous, the same species is more compactly branched and each finger is short, thick and stubby. The brain coral, *Diploria clivosa,* forms a low encrusting growth in regions of heavy surge, but in deeper water, where it is less exposed to wave movement, it tends to become more massive and to develop knobs and blunt projections.

Species found in the region of heaviest wave action on the exposed reef are usually the massive or boulder type, such as *Montastrea annularis,* the brain corals, the porous coral, *Porites astreoides* and the starlet coral *Siderastrea siderea.* There are also thick branching forms like the elkhorn coral, *Acropora palmata* and, in the outermost part of the reef, the thick columns of *Dendrogyra cylindrus,* the pillar coral. There are no fragile branches or unattached species.

At the opposite extreme of living conditions, in shallow water where sediment is present, are to be seen the finger coral, *Porites furcata,* and also the more slender form of *Porites porites,* the clubbed finger coral.

Small rounded masses of *Siderastrea radians* are also found here, along with the common rose coral *Manicina areolata*. These, together with *Favia fragum* are most resistant to the effects of sediment, fluctuating temperature, and exposure to the atmosphere during very low tides.

Some of the shallow water corals may be found in deeper water but few of the deeper water corals are able to live in shallow water. In the intermediate depths there is a good deal of intermingling.

A curious effect of sediment is often to be found in the fairly deep water behind the reef, where some of the massive corals are able to live, but where sediment is nevertheless present, and tends to settle on the upper surface of the coral boulder. The uppermost horizontal part of the surface is killed by the fine particles which settle on it but the outer, more steeply sloping sides, continue to grow so that the coral assumes a doughnut shape

Having collected the coral specimen from its particular kind of situation, there are several ways in which it may be preserved. The color of the living colony cannot be retained by any practical method, but the general appearance of the live coral is kept by preserving it in industrial ethyl alcohol of about 70% strength. If placed in this immediately the polyps will contract but they may be killed in an expanded condition if kept in a dish of seawater in the dark for a while. When fully expanded a cotton bag containing magnesium sulphate is immersed in the water. The slowly dissolving crystals narcotise the polyps so that after a while they do not contract even when placed in the alcohol preservative.

As a rule it is more convenient and quite sufficient to keep the skeleton alone, after cleaning and bleaching it. The polyps will die soon after the coral is removed from the water and the thin layer of flesh may be removed by leaving it to the scouring action of the waves on a shallow shore for a few days. Subsequent exposure to the sunlight for a few days will bleach it, especially if it is kept at alternate intervals in the seawater and the sunlight. If it is not convenient to do this, the coral may be placed in a solution of ordinary commercial laundry bleach for twenty-four hours before washing and drying in the sun.

7. LIST OF THE WESTERN ATLANTIC REEF CORALS

THE LIST which follows includes all of the known species of true reef corals which grow on the Atlantic coasts of the American continent. Among them there are a few rare species and a number of doubtful species. The latter have been included, not for any reason of taxonomic importance but because their form is sufficiently distinctive to warrant recognition in the field. Brief references regarding the validity of these species will be found in the descriptive section following the key. The system of classification adopted is that of Wells and Vaughan (1944).

Immediately below the scientific name of each species will be found the most appropriate common name available. Nevertheless, it is very probable that other names, some of which might be more suitable, are in use to greater or lesser extent. Immediately following the scientific names are letters indicating the range of distribution of the coral according to the following code:

Bd. Bermuda
Bz. Brazil
F. Florida
W. West Indies and Bahamas

CLASS ANTHOZOA

ORDER SCLERACTINIA

SUBORDER ASTROCOENIIDA

Family Astrocoeniidae

1. *Astrocoenia pectinata* Pourtales F.
(RARE ENCRUSTING CORAL)
2. *Stephanocoenia michelini* Edwards & Haime Bd., W.

Seriatoporidae	3. *Madracis decactis* (Lyman)	Bd., F., W.
Acroporidae	4. *Acropora cervicornis* (Lamarck) (STAGHORN CORAL)	F., W.
	5. *A. palmata* (Lamarck) (ELK HORN CORAL)	F., W.
	6. *A. prolifera* (Lamarck) (STAGHORN CORAL)	F., W.
SUBORDER FUNGIIDA		
Agariciidae	7. *Agaricia agaricites* (Linnaeus) (LEAF CORAL)	F., Bz., W.
	8. *A. fragilis* Dana (HAT CORAL)	Bd., F.
	9. *A. nobilis* Verrill (HAT CORAL)	F., W.
Siderastreidae	10. *Siderastrea radians* (Pallas) (STARLET CORAL)	Bd., F., W.
	11. *S. siderea* (Ellis & Solander) (STARLET CORAL)	Bd., F., W.
	12. *S. stellata* Verrill (STARLET CORAL)	Bz.
Poritidae	13. *Porites astreoides* Lamarck (POROUS CORAL)	Bd., Bz., F., W.
	14. *P. branneri* Rathbun (POROUS CORAL)	Bz., W.
	15. *P. divaricata* Lesueur (SMALL FINGER CORAL)	F., W.
	16. *P. furcata* Lamarck (FINGER CORAL)	F., W.
	17. *P. porites* (Pallas) (CLUBBED FINGER CORAL)	Bd., F., W.
	18. *P. verrilli* Rehberg (BRAZILIAN POROUS CORAL)	Bz.
SUBORDER FAVIIDA		
Faviidae	19. *Favia conferta* Verrill (GROOVED CORAL)	Bz.

20. *F. fragum* (Esper) Bd., F., W.
(STAR CORAL)
21. *F. gravida* Verrill Bz.
(STAR CORAL)
22. *F. leptophylla* Verrill Bz.
(STAR CORAL)
23. *Diploria clivosa* (Ellis & Solander) F., W.
(BRAIN CORAL)
24. *D. labyrinthiformis* (Linnaeus) Bd., F., W.
(BRAIN CORAL)
25. *D. strigosa* (Dana) Bd., F., W.
(COMMON BRAIN CORAL)
26. *Colpophyllia amaranthus* (Muller) F., W.
(ROSE CORAL)
27. *C. natans* (Muller) F., W.
(BRAIN CORAL)
28. *Manicina areolata* (Linnaeus) F., W.
(COMMON ROSE CORAL)
29. *M. mayori* Wells F.
(TORTUGAS ROSE CORAL)
30. *Cladocora arbuscula* Lesueur F., W.
(TUBE CORAL)
31. *Solenastrea bournoni* Edwards & Haime F., W.
(STAR CORAL)
32. *S. hyades* (Dana) F.
(LOBED STAR CORAL)
33. *Montastrea annularis* (Ellis & Solander) Bd., F., W.
(COMMON STAR CORAL)
34. *M. braziliana* (Verrill) Bz.
(BRAZILIAN STAR CORAL)
35. *M.cavernosa* (Linnaeus) Bd., Bz., F., W.
(LARGE STAR CORAL)

Astrangiidae

36. *Astrangia solitaria* (Lesueur) Bd., Bz., F., W.
(DWARF CUP CORAL)

Oculinidae	37. *Oculina diffusa* Lamarck Bd., F., W. (IVORY BUSH CORAL)
	38. *O. valenciennesi* Edwards & Haime (IVORY TREE CORAL) Bd., W.
	39. *O. varicosa* Lesueur Bd., F. (IVORY TREE CORAL)
Trochosmiliidae	40. *Meandrina meandrites* (Linnaeus) (BRAIN CORAL) F., W.
	41. *M. brasiliensis* (Edwards & Haime) Bz., F., W. (BRAZILIAN ROSE CORAL)
	42. *Dichocoenia stokesii* Edwards & Haime F., W. (STAR CORAL)
	43. *Dendrogyra cylindrus* Ehrenberg (PILLAR CORAL) F., W.
Mussidae	44. *Mussismilia brasiliensis* (Verrill Bz. (BRAZILIAN FLOWER CORAL)
	45. *M. hartii* (Verrill) Bz. (FLOWER CORAL)
	46. *Mussa angulosa* (Pallas) F., W. (LARGE FLOWER CORAL)
	47. *Isophyllastrea rigida* (Dana) Bd., F., W. (ROUGH STAR CORAL)
	48. *Mycetophyllia lamarckana* (Edwards Haime F., W. (LARGE CACTUS CORAL)
	49. *Isophyllia sinuosa* (Ellis & Solander) (CACTUS CORAL) Bd., F., W.
	50. *I. multiflora* Verrill Bd., F., W. (LESSER CACTUS CORAL)

SUBORDER CARYOPHYLLIDA

Caryophyllidae	51. *Eusmilia fastigiata* (Pallas) F., W. (FLOWER CORAL)

CLASS HYDROZOA

ORDER HYDROCORALLINAE

Milleporidae	52. *Millepora alcicornis* Linnaeus Bd., Bz., F., W. (FALSE OR STINGING CORAL)

8. INDENTIFICATION OF THE WESTERN ATLANTIC REEF CORALS

THE CHARACTERS used in the scientific classification of corals are difficult to study outside of the laboratory or without a detailed knowledge of their structure. Nevertheless it is possible to identify with fair accuracy the greater number of reef corals without special training, by means of the simplified key which follows. The key is based upon characters which may be seen with the naked eye or with a small hand lens, after the coral has been taken from the water and the flesh removed. A ruler graduated in centimeters and calipers for measuring the diameter of the coral cup are very useful aids.

Technical terms have been avoided as far as possible in the key, but it is advisable to read the section on coral structure before attempting to use it.

The first and most obvious character to look for is the presence of typical coral cups or calices. The false or stinging coral does not have these, but instead is covered with fine pinholes.

Some adult corals remain as single cups either completely isolated or connected only by a thin plate at the very base. The majority, however, are united to form massive structures, which may be evenly dome shaped or more irregular (Plates 14, 23, 25). Others have their cups united to form a branching structure (Plates 2, 3, 22, 28, 35, 41). The branches may each consist of a single cup (Plates 22, 41), or they may be covered with many cups. In the latter case the cups

sometimes lie flush with the surface (Plate 9). In other branching corals the cups project noticeably from the surface (Plates 2, 3, 28).

The cups of some corals are well separated (Plate 31) by the general coral surface, but in others their walls are united to form a common boundary (Plates 7, 10, 13, 36). They may also be fused longitudinally to form valleys as in the brain corals (Plates 14, 15, 16, 17). The diameter of the cup or the width of the groove from wall to wall is used as an aid to quick identification. The walls themselves may be thin, or in some cases they are wide and may develop a groove. (Plate 16).

The septa or partitions which project from the walls towards the center of the cup or groove are not all of the same size and they also vary in their distance apart. Care should be taken to count both long and short septa in determining the number of septa per centimeter. Edges of the septa may be smooth (Plates 29, 30, 33) or toothed (Plates 7, 13, 26, 34, 37) and irregular. At the inner edge of each septum there sometimes occur small plates or lobes, which are known as pali (Plate 10). In the centre of the cup a simple axial rod (Plate 1) is developed in some corals. This is the columella, which varies in form from a solid rod to a more diffuse structure. In a number of corals the upper edges of the septa extend outside the boundary of the cup over the general surface of the coral between cups. This condition is known as costate (Plate 27).

Occasionally difficulty may arise in identifying young corals. Young stages often consist of single cups, even though the adult is more complicated. Where this is likely to lead to confusion illustrations and descriptions of the young stages are given. Another possible source

of confusion is due to the considerable variation which may take place in corals as a result of the changing nature of their surroundings. In these cases a whole series of similar forms should be examined before a definite conclusion is reached. Only rarely, however, should it be necessary to use the more technical literature. This is nevertheless listed in the bibliography.

Use of the key is simple. Starting at 1, there is a choice of two descriptions. The description which more closely fits the specimen is selected. Opposite the selected description is a number which refers to another pair of descriptions further on in the key. By determining the appropriate one of these and continuing the process the reader will eventually arrive at the name of his specimen. In order to provide a quick check on the accuracy of identification references to photographic illustrations are placed throughout the key.

SIMPLIFIED KEY TO THE REEF CORALS OF THE WESTERN ATLANTIC

1. Coral has smooth surface covered with fine pinholes. No cups.
   Millepora alcicornis Linnaeus
   STINGING CORAL

   Coral surface honeycomb patterned or broken by cups or grooves .... 2.
2. Coral never forms branched or massive structure, but consists of single cups.
   Astrangia solitaria (Lesueur)
   DWARF CUP CORAL

   Cup always united to form a branched massive or encrusting structure .... 3.
3. Coral is branched (Plates 2, 3, 8, 22, 28, 35, 41) .... 4.

   Coral is not branched .... 15.
4. Cups less than 10 mm in diameter .... 5.

   Cups over 15 mm in diameter and arranged singly at end of short branches (Plates 35, 41) .... 13.
5. Cups flush with the coral surface, forming a honeycomb pat-

tern (Plate 1, 9) .... 6.
Cups projecting more or less from the coral surface (Plates 2, 3, 22, 28) .... 8.

6. Cups have slight rim, are slightly separated by the coral surface and are irregular in size and arrangement. Septa are nonporous when viewed under lens (Plate 1)
Madracis decactis (Lyman)

Cups not separated but joined by common walls. Septa are porous (Plates 8, 9) .... 7.

7. Branches have blunt swollen ends and are over 12 mm wide. Cups shallow and about 2 mm wide (Plate 9)
Porites porites (Pallas)
CLUBBED FINGER CORAL

Branches not dilated at ends and are under 12 mm wide. Cups deeper and about 1.5 mm wide (Plate 8)
Porites furcata Lamarck
FINGER CORAL

8. Cups form tubular projections on surface or ends of branches (Plates 2, 3, 22) .... 9.
Cups low in form, never elongated or tubular (Plate 28) .... 11.

9. Tubular cups about 3 mm wide, forming ends of short branches (Plate 22)
Cladocora arbuscula (Lesueur)
TUBE CORAL

Tubular cups under 2 mm wide, scattered all over thick branches which are more than 6 mm thick (Plates 2, 3) .... 10.

10. Branches flattened or fanlike (Plate 3)
Acropora palmata (Lamarck)
ELKHORN OR MOOSEHORN CORAL

Branches cylindrical (Plate 2)
Acropora cervicornis (Lamarck)
STAGHORN OR DEER HORN CORAL

11. Coral bushy with numerous short branches usually under 10 mm thick. Cups 3-4 mm in diameter (Plate 28)
Oculina diffusa Lamarck
IVORY BUSH CORAL

Coral larger and more open, branches long and crooked and usually over 10 mm thick. Cups may be 3 mm or less in diameter .... 12.

12. Main branches usually under 2 cm in diameter. Cups usually have depressions around their bases and are less than 3 mm ·in diameter

Oculina valenciennesi Edwards and Haime
LESSER IVORY TREE CORAL

Main branches 3 to 5 cm in diameter. Cups usually set upon swollen bases and are up to 3.5 mm in diameter

Oculina varicosa Lesseur
LARGER IVORY TREE CORAL

13. Septa do not have toothed edges and are about 16 to the cm (Plate 41)

Eusmilia fastigiata (Pallas)
FLOWER CORAL

Septa have toothed edges and are less than 14 to the cm (Plate 35) .... 14.

14. Septa over 12 to the cm and perforated near top. Teeth numerous and irregular. Average cup length 2.5 cm

Mussismilia hartii (Verrill)
BRAZILIAN FLOWER CORAL

Septa 8 to the cm and not perforated. Teeth larger, fewer and more regular. Average cup length 5 cms. Not found in Brazil. (Plates 34, 35)

Mussa angulosa (Pallas)
LARGE FLOWER CORAL

15. Coral forms flattened, projecting, leaflike or saucerlike plates but sometimes small knobby masses. Surface has cups arranged in parallel lines which are more or less discontinuous and separated by ridges (Plate 4) .... 16.

Coral never leaflike. Cups are not in parallel lines and may be either circular or elongate to form valleys or grooves .... 18.

16. Plates leaflike, encrusting, or sometimes uneven masses. Over 5 mm thick. Cups on both faces (Plates 4, 5)

Agaricia agaricites (Linnaeus)
LEAF OR PINEAPPLE CORAL

Plates always leaflike, not over 5 mm thick. Cups on upper face only .... 17.

17. Plates very thin and saucer shaped. Cups face nearly at right angles to surface of coral and are about 3 mm in diameter

Agaricia fragilis Dana
HAT CORAL

Plates thicker, cups set at acute angle to surface of coral and

are about 5 mm in diameter with strong parallel ridges

Agaricia nobilis Verrill
HAT CORAL

18. Surface of coral grooved by elongated and more or less branching valleys (Plates 14, 15, 16, 17, 18, 19, 20, 29, 30, 32, 37, 38) .... 19.
    Surface consists of circular, polygonal, oval or elongated cups. Valleys, if present, never very long, but narrow and unbranched (Plates 6, 11, 12, 23, 25, 27, 31, 36) .... 33.
19. Coral somewhat flattened or top-shaped, sometimes with short stalk below. Rarely grows over 6 inches (Plate 19, 30, 37) .... 20.
    Coral larger except in early growth. Forms large dome shaped, irregularly lobed or flat masses, sometimes with thick pillars (Plates 14, 15, 16, 18, 29, 32) .... 28.
20. Edges of septa appear smooth to naked eye (Plates 29, 30) .... 21.
    Edges of septa visibly toothed .... 22.
21. Coral rarely more than 6 inches long. Usually has main lengthwise valley from which smaller valleys branch out. Width of valley over 12 mm (Plate 30)

    Meandrina brasiliensis Edwards and Haime
    BRAZILIAN ROSE CORAL

    Coral grows larger. No main valley but valleys usually radiate from center. Width of valley under 12 mm (Plate 29)

    Meandrina meandrites (Linnaeus)
    BRAIN CORAL (Young Form)

22. Edges of septa have coarse teeth turned obliquely upwards (Plates 37, 39, 40) .... 23.
    Edges of septa have fine teeth not turned upwards (Plates 18, 19, 20, 21) .... 25.
23. Valleys less than 1.5 cm wide and relatively long. Thin toothed vertical plates or lamellae running lengthwise on the valley floors (Plates 37, 38)

    Mycetophyllia lamarckana (Edwards and Haime)

    Valleys 1.5 to 3.5 cm wide and relatively short. No lamellae (Plates 39, 40) .... 24.
24. Valleys average 2.5 cm wide. Septa about 8 per cm (Plate 39)

    Isophyllia sinuosa (Ellis and Solander)
    CACTUS CORAL

    Valleys average 1.5 cm wide. Septa about 12 per cm

Isophyllia multiflora Verrill
LESSER CACTUS CORAL

25. Valleys usually about 12 mm wide. No lamellae in valley floor. Base of walls 3 mm wide, or less (Plate 21) .... 26.
Coral lighter and more porous. Valleys usually over 18 mm wide. Lamellae sometimes arranged lengthwise on valley floor. Wall slopes towards middle of valley. Base of wall about 12 mm wide. Top of wall has regular shallow groove between small but distinct ridges (Plate 18) .... 27.

26. Coral may narrow towards end and may have stalk beneath. Walls over 2.5 mm thick. Septa about 18 per cm and perforated. (Plates 19, 20, 21)
Manicina areolata (Linnaeus)
ROSE CORAL
Coral never narrow at ends and never has stalk. Wall less than 2.5 mm thick. Valley deeper and narrower. Septa only 12 per cm and not perforated.
Manicina mayori Wells
TORTUGAS ROSE CORAL

27. Coral usually less than 6 inches across and stalk underneath. Valley usually over 12 mm deep. Wall about 10 mm wide at base. Septa 11 per cm.
Colpophyllia amaranthus (Muller)
Coral may be small or very large. Valley usually under 12 mm deep. Wall about 15 mm wide at base. Septa 9 per cm (Plate 18) *Colpophyllia natans* (Muller)
BRAIN CORAL (Young form)

28. Coral grows out into straight or irregularly knobbed pillars. Valleys shallow and narrow. Walls flattened. Septa lack teeth (Plate 32) *Dendrogyra cylindrus* Ehrenberg
PILLAR CORAL
Coral forms dome shaped or flat lobed masses .... 29.

29. Septa lack teeth on their edges (Plate 29)
Meandrina meandrites (Linn)
BRAIN CORAL
Septa have toothed edges (Plates 15, 16, 17, 18) .... 30.

30. Valleys about 18 mm wide and 12 mm deep. Walls grooved on top between small but distinct ridges. Septa 9 per cm (Plate 18) *Colpophyllia natans* (Muller)
BRAIN CORAL

Valleys under 10 mm wide and 6 mm deep. No ridges on wall. Septa over 14 to the cm .... 31.

31. Coral forms uneven masses with knobs or hillocks. Walls never grooved, upper margin sharp. Septa over 30 per cm (Plates 14, 15) *Diploria clivosa* (Ellis and Solander)
KNOBBED BRAIN CORAL

Coral forms more or less even dome-shaped masses. Walls less pointed and sometimes grooved. Septa less than 20 per cm 32.

32. Walls always grooved above, width of groove varying. Septa between 14 and 18 per cm (Plate 16)
Diploria labyrinthiformis (Linnaeus)
BRAIN CORAL

Walls not grooved except rarely at edge of coral. Septa between 15 and 20 per cm (Plate 17)
Diploria strigosa (Dana)
COMMON BRAIN CORAL

33. Cups 10 mm or more in width .... 34.
Cups under 10 mm in width .... 35.

34. Six to eight coarse teeth pointing obliquely upwards on edge of each septum (Plate 36)
Isophyllastrea rigida (Dana)
ROUGH STAR CORAL

Numerous teeth on edge of septum pointing horizontally
Mussismilia brasiliensis (Verrill)
BRAZILIAN FLOWER CORAL

35. Cups under 5 mm wide but may be elongated up to length 25 mm .... 36.
Cups may be more or less than 5 mm wide. If less than 5 mm wide they are never elongated beyond 5 mm .... 37.

36. Walls of cups joined. Septa with distinct teeth
Favia conferta Verrill
GROOVED CORAL

Walls of cups separate and stand out from surface of coral. Septal teeth very small (Plate 31)
Dichocoenia stokesii Edwards and Haime
STAR CORAL

37. Septal edge smooth. Cups never over 2.5 mm .... 38.
Septal edge with small teeth or beaded. Cups between 1 mm and 5 mm wide .... 39.

38. Cups well separated, with rows of small knobs marking boundary lines. Septa only protrude slightly (Plate 1)
. *Madracis decactis* (Lyman)

Cups fairly close to each other. Septal protrude above surface
Stephanocoenia michelini Edwards and Haime

39. Cups rarely exceed 2.5 mm in width .... 40.
Cups over 2.5 mm in width .... 44.

40. Coral not porous. Cups separated by about half their width
Solenastrea bournoni Edwards and Haime
STAR CORAL

Coral porous. Cups not separated but joined by common wall 41.

41. Cups 2.5 mm wide. Septa protrude above surface of coral
Astrocoenia pectinata Pourtales
RARE STAR CORAL

Cups under 2 mm wide. Septa do not protrude beyond surface of coral .... 42.

42. Cups 0.9 to 1.2 mm wide
Porites branneri Rathbun
POROUS CORAL

Cups 1.2 to 1.5 mm wide .... 43.

43. Shallow cups with thin wall less than 0.4 mm (Plate 11)
Porites astreoides Lamarck
POROUS CORAL

Deeper cups with wall about 0.4 mm
Porites verrilli Rehberg
BRAZILIAN POROUS CORAL

44. Cups circular and over 6 mm in diameter .... 45.
Cups do not exceed 6 mm in diameter .... 47.

45. Cups closely touching, forming double walls
Favia lephtophylla Verrill
BRAZILIAN CORAL

Cups up to 5 mm apart. Never form double walls (Plate 27) 46.

46. Coral between cups blistered in appearance
Montastrea braziliana Verrill
BRAZILIAN STAR CORAL

Coral between cups not blistered but ridged by extensions of septa. (Plate 27) *Montastrea cavernosa* (Linnaeus)
LARGE STAR CORAL

47. Cups either separated, or if touching, walls not fused (Plates 24, 25) .... 48.
Cups have common walls (Plates 6, 7, 13) .... 50.

48. Cups usually close together, varying considerably in size and shape, and walls well raised above surface.
Favia gravida Verrill
BRAZILIAN STAR CORAL
Cups usually 1 to 3 mm apart, more regular in shape and walls only slightly raised (Plate 24, 26) .... 49.

49. Surface of coral blistered in appearance. Septa do not extend between the cups. Cups often angular when crowded (Plate 24) *Solenastrea hyades* (Dana)
LOBED STAR CORAL
Surface of coral not blistered. Septa extend over space between cups (Plate 26) *Montastrea annularis* (Ellis and Solander)
COMMON STAR CORAL

50. Septa protrude above surface, extending over common wall, and relatively well separated. Edges of septa irregularly hooked (Plate 13) *Favia fragum* (Esper)
STAR CORAL
Septa not so prominent, and are evenly crowded together (Plates 6, 7) Septa beaded. .... 51.

51. Cups irregular in shape, 2 to 3 mm wide and up to 6 mm long.
Siderastrea stellata Verrill
STARLET CORAL
Cups more regularly pentagonal, up to 5 mm wide (Plates 6, 7) .... 52.

52. Cups 2.5 to 3.5 mm. Septa with inner margins almost perpendicular so that cavity is narrow and straight sided (Plate 6) *Siderastrea radians* (Pallas)
STARLET CORAL
Cups 3.5 to 5 mm. Septal margins sloping so that cavity is more open (Plate 7) *Siderastrea siderea* (Ellis and Solander)
STARLET CORAL

9. DESCRIPTION OF THE WESTERN ATLANTIC REEF CORALS

THE FOLLOWING brief descriptions of the corals found upon the reefs of the Western Atlantic ocean are written primarily for those who have no acquaintance with the technicalities of coral taxonomy. A technical description is appended for the use of students, however, and is printed in italics.

Since the coral may have been referred to by other names in previous descriptions the more important of these are indicated together with the publication in which they appeared. All references to publications are made by placing the date of publication in brackets after the author's name. The full title and source will be found under this reference in the bibliography. No attempt has been made to give the detailed synonymy of the corals described, but the name adopted is, as far as can be determined, that accepted by the most recent authors.

Following the synonym will be found a reference to the best available published description. This is not necessarily the most complete. In selecting it, the quality of illustrations and the availability of the literature has been taken into account. Often the original description may be the most complete, but nearly as often this is hidden away in journals that are to be found in very few libraries.

1. *Astrocoenia pectinata* Pourtales.

Originally described by Pourtales (1879). No later description available.

Coral forms a thin crust on rock or dead coral. Rather porous. Cups polygonal and about 2.5 mm in diameter. The septa or radial plates have beaded margins. Rare. Known only as one small colony found by Pourtales.

Encrusting. Cerioid. Porous. Calices 2.5 mm, polygonal. Columella well developed, styliform. Septal margins beaded. No perítheca. Septa of relatively few simple trabeculae strongly inclined from axis of divergence. Exsert. No pali.

2. *Stephanocoenia michelini* (Edwards and Haime).

Also *Stephanocoenia intersepta* Vaughan (1919). Also *Plesiastrea goodei* Verrill (1902).

Described by Vaughan (1919), page 357.

Polyps brown in color. Coral appears very similar to *Siderastrea radians*. Forms rounded boulders under one foot in diameter. Rather porous. Cups close together but not always touching, and between 2 and 3 mm in diameter. Radial septa smooth or very finely toothed. Distinguished from *Siderastrea radians* by the presence of lobes or pali at the inner edges of the septa.

Grows throughout the West Indies, the Bahamas, Florida and Bermuda but not very commonly found, possibly because of its resemblance to *Siderastrea radians* when alive.

Massive, subhemispherical. Plocoid or sub-ceriod. Sometimes costate. Calices 2 to 3 mm in diameter. Septa in three cycles. Exsert. Primaries and secondaries with well developed pali. Tertiaries thin and shorter. Septal margins entire or finely dentate. Columella same height as pali, in form of a compressed style. Thin, sub-horizontal endothecal dissepiments about 0.5 mm apart.

3. *Madracis decatis* (Lyman), (Plate 1).

Described by Verrill (1902), page 108.

Polyp yellow to purple-brown in color with white tips to tentacles and lining mouth. Coral forms thin encrustations on rock, sometimes growing out into sparse branches or lobes. Usually under six inches. Cups do not touch, angular or circular with ridged boundary, about 2 mm in diameter. Common in Bermuda and found throughout the Bahamas and the West Indies.

Thinly encrusting, irregularly massive or lobulated or in short stout branches. Plocoid. Ridges bounding calices. Non-costate. Smooth septa, somewhat reduced, Columella styliform, well developed. Peritheca extensive, non-porous. Septa usually 10, sometimes 8.

4. *Acropora cervicornis* (Lamarck), (Plate 2).

Also *Acropora muricata* (Vaughan 1919). Also *Isopora muricata* (Vaughan 1901).

Discussed by Vaughan (1901), page 312 and (1919), page 482.

Brownish yellow. Coral forms loosely branched colony with small tubular cup protuding over entire surface. May grow to 10 feet high. Abundant in Florida, the Bahamas and the West Indies, but not in Bermuda or Brazil.

Ramose colonies, branches consisting of an axial corallite with radial corallites budded from it. Corallites protuberant, tubular or nariform, 1 to 3 mm long, with porous walls. Synapticulothecate. Septa well developed. Pseudo-costate.

5. *Acropora palmata* (Lamarck), (Plate 3).

Also *Isopora muricata* forma palmata (Vaughan 1900).

Discussed by Vaughan (1901), page 313 and 1919), page 482.

Brownish yellow. Coral forms flat frond-like branches resembling somewhat the horns of an elk. Other characteristics similar to *A. cervicornis*, of which it has been considered a variety. Found throughout Florida Keys, the Bahamas and the West Indies.

Corallites similar to A. cervicornis. Branches flabelliform or frond-like, flattened in more or less horizontal plane.

6. *Acropora prolifers* (Lamarck).

Also *Isopora muricata* forma prolifera (Vaughan 1901).

Discussed by Vaughan (1901), page 313, and (1919), page 482.

Brownish yellow. Similar to *Acropora cervicornis* with branches joining where they cross so as to form flattened plates. Has been considered merely a variety of *Acropora cervicornis* which is intermediate between that species and *Acropora palmata*, also considered a variety. The validity of these species is discussed by Vaughan. Found throughout Florida Keys, the Bahamas and the West Indies.

Corallites similar to A. cervicornis. Branches more crowded, however, tending to fuse into flabelliform growths.

7. *Agaricia agaricites* (Linnaeus), (Plates 4, 5).

Also *Agaricia crassa* Verrill, (Verrill 1902), also *Agaricia purpurea* Lesueur, (Verrill 1902).

Described by Verrill (1902), pages 140-150 and by Vaughan (1919), page 427.

Chocolate to purple-brown. Short white tentacles. Coral forms more or less erect fronds covered with cups

on both faces, as a rule. Sometimes due to growth conditions (see Vaughan), the fronds may be reduced and an almost massive, slightly lobed form result (variety crassa). Sometimes the cups may be restricted to one face (variety purpurea). Cups arranged in parallel groups of varying lengths separated by slightly projecting walls. Common on the Florida reefs in the Bahamas and southward to Brazil.

Coral usually foliaceous or frondous, but sometimes massive or encrusting. Fronds usually bifacial, irregular 5 to 20 mm thick. Calices arranged in groups between more or less parallel collines, small and shallow, about 2-3 mm. Septa low, up to 36, finely serrulate. Costate. Synapticulae between septa.

8. *Agaricia fragilis* Dana.

Described by Verrill (1902), page 142.

Generally similar to *A. agaricites,* with the following differences. Coral grows out into cup shaped or saucer shaped fronds, which are thin and delicate. Usually up to 6 inches across and with cups on upper surface only. Ridges between cups generally long and low. Cups about 2 mm across. The only Bermuda species of *Agaricia.* Also off Florida Keys.

Pedicelled, with broad thin saucer-shaped or cup-shaped frond, unifacial, about 3 mm thick. Rarely over 150 mm. Calices small, about 2 mm, generally with edges elevated. Septa and costae thin and finely serrulate. Collines vary, but usually long, regular, rounded and little elevated, forming long concentric series of calices. Septa up to 24. Collines about 20 mm apart.

9. *Agaricia nobilis* Verrill.

Described by Verrill (1902), page 150.

Grows in thin fronds or cups, not as small or delicate as those of *A. fragilis*, but thinner than those of *A. agaricites*. Cups on upper surface only. Under surface covered with fine ridges. Chocolate to purple brown in color. The cups are in small groups of three or four. They are separated by walls which are strongly inclined towards the edge of the frond, so that they appear as if supported in brackets. As many as 48 septa in each cup. Cups about 4 mm across. Not common. Florida reefs, the Bahamas and the West Indies.

Pedicelled with rounded, concave or flat fronds varying from 1 to 5 mm thick. Costal striae cover under surface. Calices on upper surface in small groups of 3 to 6, separated by prominent, fairly short curved collines set at an acute angle to the frond and facing towards edge of the frond. Calices up to 5 mm, fairly deep, with 36 to 48 finely serrulate septa. Septo-costae about 10 mm.

10. *Siderastrea radians* (Pallas), (Plate 6).

Described by Vaughan (1919), page 439.

Corals form rounded or pebble shaped stones up to 1 foot or more across, but sometimes when young forms encrustations. Grayish to brown in color. Cups small, about ? mm and angular. Inner edges of septa perpendicular, cavity of cup deep and narrow. Distinguished from S. *siderea* by smaller cup and deep narrow cavity. Very common in shallow water in Bermuda, Florida, the Bahamas and the West Indies to South America and Colon.

Spheroidal or hemispherical masses up to 500 mm diameter. Often encrusting or irregular when young, or loose on bottom. Cerioid. Calices 2.5 to 3.5 mm,

angular. Septa 36 to 40, four unequal cycles, first two very distinct from others, last cycle incomplete. Larger septa slightly exsert, serrulate, inner edges perpendicular. Columella small and papillose.

11. *Siderastrea siderea* (Ellis and Solander), (Plate 7).

Described by Vaughan (1919), page 443.

Larger masses than *S. radians*, sometimes over 2 feet. Cups 4 to 5 mm across. Septal margins slope more than *S. radians* so that cup is larger and shallower. Septa 50 to 60. Common on Florida reef, Bahamas, West Indies and Bermuda.

Hemispherical masses up to 2 or 3 feet in diameter. Calices up to 4-5 mm sometimes 6 mm in diameter, wall slightly raised. Three or 4 rows of synapticulae on each side of wall between septa. Septa in five cycles, last cycle incomplete. Less difference in size of septa than S. radians. Septal margins more sloping and more finely dentate. Columella small.

12. *Siderastrea stellata* Verrill.

Described by Vaughan (1919), page 440.

Similar to *S. radians*, but cups deeper and more irregular. Found only in Brazil, where it is widely distributed on the Abrolhos reef and at Bahia.

Calices irregular 2-3 mm wide and up to 6 mm or more long. Cerioid. Four cycles of septa, last cycle incomplete. Inner margins of septa very steep, more coarsely dentate than S. radians. Columella finely papillate and less developed than in S. radians.

13. *Porites astreoides* Lamarck, (Plate 11).

Described by Verrill (1902), page 160.

Usually yellowish brown in color. Forms rounded masses, covered with small bumps and growing to up to more than 2 feet. Cups from 1.25 to 1.50 mm in

diameter. Septa have small rough teeth and are porous, 12 in number. Abundant from Florida reef and Bahamas to Brazil. Also present at Bermuda.

Encrusting when young, massive subnodular, calices 1.25 to 1.50 mm in diameter. Twelve septa, porous, rarely distinct pali. Columella very small, porous. Calices larger, deeper and with higher and more distinct walls than P. porites.

14. *Porites branneri* Rathbun.

Described by Verrill (1902), page 162.

Very porous rounded masses up to six inches, formed by thick encrustations over stones or dead coral. Small cups about 1 mm across. Inner edges of septa join to form a ring. Found on Brazilian reefs and possibly in the West Indies.

Thick rounded encrustations, 3-6 inches, covering dead coral. Calices small and shallow, crowded, polygonal, with thin fenestrated walls, diameter 0.9 to 1.2 mm. Septa 12, narrow, spiny and fenestrated, inner edges uniting to form columelliform ring. Pali, when present, 3 to 5, slender, erect.

15. *Porites divaricata* Lesueur.

Discussed by Vaughan (1901), page 316.

Although this is probably a variety of *P. furcata* or *P. porites* it is distinct in appearance. The branches are much smaller than *P. furcata,* under 6 mm in diameter with no tapering or dilation along the length of a branch. Florida, Bahamas and the West Indies.

Branches less than 6 mm diameter, same at proximal and distal end, calices very shallow, 2 mm in diameter. Wall narrow, rather flat or subacute.

16. *Porites furcata* Lamarck, (Plate 8).

Discussed by Vaughan (1901), page 316.

Branching colonies, branches thicker than *P. divaricata,* but without the swollen ends of *P. porites.* Cups smaller than in *P. porites.* Florida, Bahamas, and the West Indies.

Ramose. Branches vary in diameter about 10 mm, ends never clubbed. Calices about 1.5 mm in diameter, usually only five pali.

17. *Porites porites* (Pallas), (Plates 9, 10).

Also *Porites polymorpha* Link, (Verrill 1902), also *Porites clavaria* Lamarck, (Vaughan).

Described by Vaughan (1901), page 314.

This name has been used to include all the branched species of *Porites.* The question of species versus varieties is discussed by Vaughan (1901).

Branched, larger branches than *P. furcata,* with ends swollen and blunt. Columella and pali usually present. Found throughout the Western Atlantic reef areas, except Brazil.

Colony forms thick clumps of irregular stout branches, swollen at ends. Calices shallow, deeper on ends of branches, 2 mm in diameter. Columella represented by tubercle and surrounded by six pali which are less developed in the calices at ends of branches. Septa perforate.

18. *Porites verrilli* Rehberg.

Described by Verrill (1902), page 161.

Massive, similar to *P. astreoides* but larger and more solid. Cups deeper, and separated by thicker, more solid and prominent walls. Common on coast of Brazil.

Larger and more solid than P. astreoides. Calices deeper. Walls more solid, thicker and prominent. Pali rudimentary or absent. Columella large, solid and tuberculate, sometimes with slight styliform projection.

19. *Favia conferta* Verrill.

Described by Verrill (1868), page 355.

Discussed by Vaughan (1901, page 304.

Encrusting masses, never very large. Yellowish brown in color. Cups irregular in shape, also short valleys separated by narrow walls. Septa similar to *F. fragum*. Only at Brazil.

Encrusting or sub-massive up to a few inches. Intratentacular budding. Monostomodoeal polyps or short series, forming curved but not sinuous valleys, separated by small narrow collines. Otherwise similar to F. fragum. Costate, septa exsert. Septal margins irregularly dentate. Columella parietal, spongy.

20. *Favia fragum* (Esper) (Plates 12, 13).

Discussed by Vaughan (1901), page 303.

Forms small crusts on other rocks or small rounded pebbles an inch or two long. Light yellow to brown. Cups angular, circular or oval, under 6.5 mm across. Septa have irregular teeth on margins. Bermuda, Florida, the Bahamas and the West Indies. Common in shallow water.

Encrusting or capuliform masses or subhemispherical, up to 50 mm. Calices circular, angular or elliptical. Under 6.5 mm in diameter. Average 4.5 mm or less. Walls 1.5 mm or more. Septa from three to nearly four complete cycles, 36 to 40, margins irregularly dentate. Costae acute, dentate. Columella large, spongy.

21. *Favia gravida* Verrill

Described by Verrill (1868), page 354.

Similar to *F. fragum*. Walls of cups stand out above surface and separate from each other. Cups oval or deformed by crowding, never elongated into valleys. Brazil only.

Plocoid. Small, encrusting or subhemispherical. Margins of calicinal walls projecting beyond perithecal surface. Circular or oval calices, never much elongated, similar to F. fragum. Four complete cycles of septa.

22. *Favia leptophylla* (Verrill) .

Also *Orbicella aperta* Verrill. .

Verrill (1868), page 353.

Distinguished from *F. fragum* and *F. gravida* by more massive growth up to 2 feet. Cups about 6 mm. Walls of cups thin, separated by blistered coral. Septa project well over top of wall. Confined to Brazil.

Massive, up to 2 feet. Plocoid. True walls thin with loose vesicular exotheca between calices. Calices 6 mm. Septa rather few, thin, prominent and exsert. Interseptal loculi wide and deep.

23. *Diploria clivosa* (Ellis and Solander), (Plates 14, 15).

Also *Meandra clivosa,* (Vaughan 1919, Verrill 1902), also *Meandrina clivosa,* (Matthai, 1928).

Described by Matthai (1928), pages 71-76.

Greenish brown in grooves, chocolate colored over walls, tentacles bright green, white towards tips. Rather large, heavy, but low growth with irregular knobs over surface. Valleys not all connected together, shallow and narrow, very winding except at edge. Walls never grooved. Septa thin and close together. Florida and West Indies but not Bermuda or Brazil.

Corallum heavy, spreading. Calicinal surface uneven with short irregular billocks. Valleys discontinuous, width up to 6 mm, average 3.75 mm, depth 3.5 to 4 mm, usually very sinuous but straight towards edge of corallum. Colline rather sharp at summit, 1 to 1.5 mm thick, never grooved. Septa thin, 30 to 40, average

35 per cm, in two alternate series. Principal septa with rather thick paliform lobes. All septa continuous over colline, exsert ends angular. Columella well developed, of closely twisted trabeculae about 1 to 1.2 mm in width.

24. *Diploria labyrinthiformis* (Linnaeus), (Plate 16).

Also *Meandrina labyrinthiformis,* (Matthai, 1928), also *Meandra labyrinthiformis* (Verrill, 1902).

Described by Matthai (1928), pages 63-71.

Color bright orange yellow to brownish yellow. Forms large rounded boulders. Valleys twisting, narrower and deeper than D. *strigosa,* nearly all interconnected. Walls thick, with a longitudinal groove, which is sometimes wider and deeper even than the valleys. Septa thicker and not quite so closely arranged as D. *strigosa.* Abundant in area behind reef edge, Bermuda, Bahamas, Florida and the West Indies. Not Brazil.

Hemispherical, evenly convex, heavy masses up to 6 or 8 feet diameter. Valley very sinuous except at edge of corallum, almost continuous, width up to 8 mm, average 5 mm, depth 5 mm. Colline thick, vesicular peritheca up to 20 mm, average 8 mm. Ambulacrum invariably grooved up to 22 mm in width, average 5 mm and up to 12 mm deep, average 6 mm. Septa 14-17 per cm, nearly all meeting columella, thicker than D. strigosa. Broad paliform lobes. Close, blunt, septal teeth, uppermost directed obliquely upwards. Principal septa exsert 1 mm, with costae. Columella well developed of thin, closely twisted trabeculae.

25. *Diploria strigosa* (Dana), (Plate 17).

Also *Platygyra viridis* (Lesueur), Vaughan 1901, also *Meandra cerebrum* (Ellis and Solander), Verrill,

1902, also *Meandra strigosa* (Dana), Vaughan 1919, also *Meandrina cerebrum* (Ellis and Solander), Matthai, (1928).

Described by Matthai (1928), pages 55-63.

Dull yellow to greenish brown in color. Dome shaped masses, smaller than *D. labyrinthiformis*. Valleys twisting, not all interconnected, wider and deeper than *D. clivosa*. Walls between valleys wider than *D. clivosa*, but rarely grooved as in *D. labyrinthiformis*. If present, grooves narrow and shallow, and usually at edge of coral. Septa continue over the walls. Bermuda, Florida, the Bahamas and the West Indies.

Hemispherical, evenly convex. Valleys sinuous, discontinuous, up to 9 mm wide, average 6 mm, about 5 mm deep. Colline up to 4.5 mm thick, average 2.5 mm. Septa 15-20 per cm. Paliform lobes. Septal margins dentate, sides spinulose. Septa exsert and arched over colline. Colline rarely with shallow, narrow, grooves at edge of corallum. Columella, closely twisted trabeculae.

26. *Colpophyllia amaranthus* (Muller).

Described by Matthai (1928) pages 107-109.

Small and light, slightly convex mass with short stalk beneath. Valleys green, walls brown. Valleys fairly short and straight, not interconnected, grooved above with thin boundary ridges. Florida and West Indies.

Small, massive, vesicular, light, and slightly convex. Short stalk beneath. Valleys discontinuous and fairly straight, often short, width 15-20 mm, up to 35 mm at edge of corallum. Depth of valley 15 mm average, up to 30 mm, shallower between centers. Colline at base up to 20 mm, average 10 mm, swollen by vesicular endotheca, grooved above. Groove about 2 mm wide,

1 mm deep, bounded by thin plates of original thecae. Septa 10-12 per cm, 6 or 7 meeting columella, notch in septum simulates paliform lobe. Slightly exsert, rarely meeting in colline groove. Columella rudimentary, columellar centers sometimes connected by thin toothed septal lamellae. Costae on non-calicinal surface.

27. *Colpophyllia natans* (Muller), (Plate 18).

Described by Matthai (1928) pages 101-107.

Large, light convex mass. Valleys more or less interconnected and winding, shallower than C. *amaranthus*. Wall grooved as in C. *amaranthus*. Valleys green, walls brown. Florida, Bahamas and West Indies.

Large massive, vesicular, light convex masses. No stalk. Valleys sinuous, usually continuous, width 15-20 mm up to 30-40 mm at edge, depth up to 17 mm, average 11, shallower between centers. Colline thickened at base to 22 mm, average 17 mm. Septa 8 or 9 per cm, 5 or 6 meeting columella. Otherwise similar to C. amaranthus.

28. *Manicina areolata* (Linnaeus), (Plates 19, 20, 21)

Described by Matthai (1928), pages 80-91.

Yellow to brown with greenish valley, tentacles transparent, with white tips. Form varies, usually roughly oval with narrow ends and flattish upper surface and converging to a short stalk below. Never more than about 6 inches long. Valley branches out into side arms, up to one inch wide. Septa seen under lens have fine holes, about 18 to the centimeter and thinner than in *M. mayori*. Very common in Florida, the Bahamas and the West Indies in shallow water.

Corallum narrow towards ends, small. Upper surface flat or convex, sometimes lobular, underneath with central short stalk. Valley continuous with median

straight portion and paired lateral branches or sinuous, width up to 24 mm, usually 12-15 mm, depth up to 21 mm, usually 8 mm. Colline averages 3.5 mm, thick up to 9 mm, with narrow shallow grooves when thick. Septa thin, 15-20 in one cm, 6-9 meeting columella. Principals have upper two-thirds narrow, and lower part raised into high, broad, convex or rounded paliform lobes. Perforate. Sides spinulose. Exsert ends meet in notches in middle of colline. Columella up to 4 mm thick. Costae narrow and thin about 1 mm apart at margin of corallum, covered by thin epitheca.

29. *Manicina mayori* Wells.

Also *Manicina gyrosa* (Ellis and Solander), (Matthai, 1828, Vaughan 1919, Verrill 1902).

Described by Matthai (1928) pages 91-94.

Color similar to *M. areolata.* Not narrow at ends and larger than *M. areolata.* No central stalk. Valley not completely interconnected, long and winding, about same size as *M. areolata.* Wall thinner, septa thicker, about 12 to the cm, and without holes. Found at Dry Tortugas, Florida.

Massive, not narrow at ends, heavy, large. No central stalk. Discontinuous valley, long and sinuous, sometimes straight, about 12 mm wide up to 20 mm at edge, about 10 mm deep. Colline about 2 mm. Septa 12 per cm, majority meeting columella. Upper two-thirds narrow, lower part arched to simulate paliform lobes. Not perforate. Exsert ends meet in groove of colline. Columella 2.5 to 3 mm thick. Costae about 1 mm apart and sometimes covered by thin epitheca.

30. *Cladocora arbuscula* Lesueur, (Plate 22).

Small densely branching form, each short branch ending in a cup. Cups about 3.5 mm in diameter,

branches slightly larger. Branches with fine longitudinal ridges continuous with the septa. Florida, the Bahamas and the West Indies.

Small, densely branching phaceloid corallum, arising by extratentacular budding. Corallite about 4 mm in diameter, calices 3 to 3.5 mm. Finely dentate septa, usually about 36, paliform lobes merging with papillose columella. Low ridges on surface of corallite corresponding to septa.

31. *Solenastrea bournoni* Edwards and Haime.

Described by Vaughan (1919), page 399.

Coral forms domes or rounded pebbles up to 1 foot in diameter, sometimes with irregular bumps on the surface. Cups, smaller than *S. hyades*, about 2 mm in diameter and separated by about 1 mm. Low ridges extend from the septa part way across the space between cups, which is somewhat blistered. Florida and West Indies.

Corallum hemispherical or spheroidal, uniformly rounded or with gibbosities. Calices with slightly elevated margins, 2 to 2.5 mm diameter, and about half this distance apart. Costae short. Exotheca vesicular. Septa thin, in three cycles, tertiaries alone not reaching columella. Pali thin and rather wide before first two cycles. Septal surfaces finely granulate, imperforate, small columella.

32. *Solenastrea hyades* (Dana), (Plates 23, 24).

Also *Orbicella excelsa* Dana, (Verrill 1902).

Discussed by Vaughan (1919), page 395.

Yellow brown in color. Grows in lobed masses or irregular crusts. Cups about 3 mm across with rims slightly raised above the surface. Cups almost touching or separated by as much as 3 mm . Septa do not

extend across spaces between cups, which may be more or less blistered in appearance. Florida Reefs, Bahamas and West Indies.

Calices nearly circular, but angular when crowded, 3 to 3.5 mm in diameter, borders often slightly elevated above exotheca. Calices sometimes touching or separated by as much as 2-3 mm. Walls thin, costae thickened, minutely serrulate and never extending across exothecal spaces. Exotheca smooth or vesicular. Septa 12 to 24, 12 extend to columella. Those of third cycle bend toward and join the larger ones. Septa thin at columella, thickened at wall, inner edge serrulate, sides roughly granulated. Small paliform lobes. Columella small, of small twisted septal processes.

33. *Montastrea annularis* (Ellis and Solander), (Plates 25, 26).

Also *Orbicella annularis,* (Vaughan 1919), also *Orbicella hispidula* (Verrill 1902), also *Orbicella acropora* (Linnaeus), (Vaughan 1901).

Discussed by Vaughan (1919), page 365.

Grows into boulders 5 feet or more across, forming one of the principal reef forming corals of the West Indies. Sometimes more encrusting or more irregular in shape. Yellow brown in color. Cups circular, 2 to 2.5 mm in diameter and an average of 1 mm apart. Rims slightly projecting. Septa prolonged across space between cups. Florida, the Bahamas, the West Indies and Bermuda.

Calices more or less circular, diameter varies, 2 mm to 2.5 mm, margins more or less raised above exotheca, 0.5 to 2 mm apart. Costae corresponding to all septa, edges dentate, those of adjoining calices meeting. Septa in three complete cycles, those of first two equal, fusing

with columella, tertiaries shorter, inner edges free. Margins of first two cycles exsert. Septal margins dentate, sides finely granulate. Columella well developed from interlacing septal processes, one third diameter of calice. Endothecal dissepiments thin, exothecal dissepiments thick, both horizontal.

34. *Montastrea braziliana* (Verrill).

Also *Orbicella braziliana*, (Verrill 1902), also *Orbicella cavernosa*, (Quelch 1886).

Forms rounded masses up to 2 feet in diameter. Differs only from *M. cavernosa* in having strongly blistered appearance between cups and in more uniform thickening of septa. Brazil only.

According to Quelch, this differs from O. cavernosa only by the highly vesicular exotheca, which hides the costae and in the uniform thickening of the septa.

35. *Montastrea cavernosa* (Linnaeus), (Plate 27).

Also *Orbicella cavernosa*, (Vaughan, 1919 and Verrill, 1902).

Described by Vaughan (1919), page 380.

Forms boulders which may be over 5 feet across. Large cups, average 8 mm across, usually projecting above surface. Septa prolonged into space between cups. Rare in Bermuda but common in Florida, the Bahamas and the West Indies.

Corallum massive, growing to considerable size, upper surface flat, irregularly convex or domed. Calices more or less elevated, diameter 5 to 11 mm close together or separated as much as 6 mm. Costae well developed, denticulate, rounded, about 48. Septa 48, exsert, serrulate, in four cycles, those of first three reach columella, others may be reduced or lacking. Columella well developed, broad, with a papillany upper surface.

36. *Astrangia solitaria* (Lesueur).

Described by Vaughan (1901), page 298.

Cups single, growing attached to base of larger corals or to dead rock, sometimes with thin encrustation connecting bases of several cups. Cups, tubular about 6 mm tall and 4 mm in diameter. Most of septa with toothed edges. Septa prolonged as low ridges down side of cup. Not strictly a reef coral, but found in reefs from Bermuda to Brazil.

Solitary or phaceloid, separate corallites sometimes joined by thin encrustations of peritheca. Average height of corallite 5-6 mm, diameter 5 mm. Low, flat, equal costae, densely granulate, distinct down to base of corallite. Four cycles of septa, 4th incomplete 1st and second reach columella, third bend in to join second and fourth bend and fuse with third. None of septa very exsert, all denticulate, less marked in first and second cycles. Columella weak and spongy.

37. *Oculina diffusa* Lamarck, (Plate 28).

Described by Verrill (1902), page 175.

Consists of close bushy branches bearing shallow cups, each about 3.5 mm across. Branches less than 10 mm thick, usually. Very abundant, Florida, Bermuda, the Bahamas and the West Indies. Not Brazil.

Forms densely ramose colony by alternate extratentacular building, no axial corallite. Calices 3-4 mm in diameter, sometimes circumvallate, septa usually 24, rather narrow, slightly exsert. Well developed columella.

38. *Oculina valenciennesi* Edwards and Haime.

Described by Verrill (1902), page 176.

Larger and more straggling compared to O. *diffusa*. Cups slightly sunken with groove surrounding them,

slightly larger than O. *diffusa*. Found in Bermuda and the West Indies, not so far in Florida.

Branches more open and irregular than O. Diffusa, often over 1 foot high. Larger branches 12 to 20 mm in diameter in large specimens. Corallites usually circumvallate, low and scarcely exsert. Curved costal striations cross circumvalleys. Calices average 4 mm ranging from 3-5 mm in diameter.

39. *Oculina varicosa* Lesueur.

Described by Verrill (1902), page 173.

The largest of the ivory corals up to 2 feet high. Branches fewer and longer than O. *diffusa* and O. *varicosa*, and main part much wider. Cups swollen at base, except on smaller branches, with bottom 10 mm or more across, and top 3.5 mm. Comparatively rare, found in Bermuda and occasionally on the Florida Reef and in the West Indies.

Branching irregular, arborescent, main trunk up to 50 mm, branches long, crooked and tapering. Corallites mammiform, bases less swollen at tips of branches. Costal striae well developed, about 24, sometimes lacking on larger branches. Septa 24 to 36, rarely more in large corallites. Calices 2.75 to 3.50 mm in diameter, rarely 4 mm, bases of corallites up to 12 mm wide and 8 mm high.

40. *Meandrina meandrites* (Linnaeus), (Plate 29).

Also *Pectinia meandrites*, (Matthai, 1928).

Described by Matthai (1928), pages 161-166.

Forms large boulders, flat or rounded, up to over 1 foot. Valleys long and twisting but not all interconnected, about 10 mm wide, 8 mm deep. Wall has groove about 2 mm wide and about 4 mm deep. About 7 larger septa per cm, over 1 mm thick, no teeth on

margins, with smaller septa alternating. Found in Florida and the West Indies.

Massive, heavy, flat, convex or irregular. Discontinuous valleys, long and sinuous, 8-14 mm wide, average 11 mm, 6-10 mm deep, average 8 mm. Rarely short valleys. Colline, with groove up to 4 mm wide, average depth 1.5 mm, up to 5 mm, rarely discontinuous. Principal septa 6.8 per cm, 1.2 mm thick, 4.5 mm deep. Margins of septa vertical, entire with granules on sides. Smaller narrow septa alternate. Septa exsert 1 to 1.5 mm, exsert ends arched. Columella lamellar, sometimes of twisted solid trabeculae or two or three parallel lamellae, continuous. Sometimes rudimentary or discontinuous.

41. *Meandrina brasiliensis* (Edwards and Haime).

Also *Pectinia brasiliensis*, (Matthai 1928).

Described by Matthai (1928), pages 167-169.

Smaller than *M. meandrites.* Flat or rounded on top, conical below with short stalk. Valleys interconnect usually with side valleys opening off a single lengthwise central valley. Otherwise smilar to *M. Meandrites.* Not very common. Brazil, Florida reef and the West Indies.

Turbinate, somewhat convex, short peduncle. Continuous valley with midlongtitudinal and paired lateral lobes as in Manicina areolata, width 15-20 mm. Colline somewhat thickened with groove about 2 mm wide, or ridged, about 2 mm thick.

42. *Dichocoenia stokesii*, Edwards and Haime, (Plate 31).

Described by Matthai (1928), pages 198-201.

Forms heavy boulders up to one foot in diameter. Short valleys, separate from each other, walls project-

ing from general surface. Septa thick, without teeth. Found on Florida reefs, in the Bahamas and in the West Indies.

Convex or rounded, heavy. Narrow, short discontinuous valleys. Mono-, di-, and tri-stomodoeal polyps. Intramural budding. Valleys slightly curved, up to 28 mm long, 3-5 mm wide, 4-5 mm deep, lateral branches or terminal forks rare. Walls vary in amount of projection, up to 7 mm. Walls 1 to 1.5 mm thick, and up to 5 mm apart towards edge of corallum. Peritheca granular or vesicular. Septa alternately thick and thin, about 10 of each per cm. Thick septa about 0.75 mm towards wall. 5-8 thin septa and all thick septa meet columella. Thick septa exsert to 1 mm, lower broadened parts sometimes form paliform lobes. Columella of closely twisted trabeculae, 1 mm broad. Costae correspond to septa, but thicker, with granular edges.

43. *Dendrogyra cylindrus* Ehrenberg, (Plates 32, 33).

Described by Matthai (1928), page 170.

Forms heavy pillars up to 2 feet long, wide at base. Winding, narrow valleys, not all interconnected. Thick septa without teeth. Narrow walls between valleys. Found on the Florida reef, in the Bahamas and in the West Indies.

Heavy, massive, rising into cylindrical branches which may reach 60 cms in length, with a broad base up to 20 cms in diameter. Sinuous, discontinuous valleys, often short, 3-4 mm wide, 2.5-3 mm deep. Collines average 3 mm thick, up to 5 mm, usually with shallow groove. Septa non-dentate, sides granular, alternately thick and thin, 7-10 per cm. Thick septa, 1 mm thick, meet columella, exsert up to 1.25 mm. Exsert portion

arched with sharp margin, terminating at edge of groove. Columella solid, 1 mm thick, centers not marked. Sometimes reduced columella and septa, meeting across valley.

44. *Mussismilia brasiliensis* (Verrill).

Also *Protomussa brasiliensis,* (Matthai, 1928), also *Mussa (Symphyllia) brasiliensis,* and *Mussa (Symphyllis) tenuisepta,* (Verrill, 1902).

Described by Matthai (1928), page 269.

Cups up to 25 mm long, irregularly oval, separated by grooves. Septa with teeth not directed upwards as in *Mussa.* Found only on the Brazilian reefs.

Massive and heavy, calicinal surface convex, lower surface with broad attachment. Mono-, di- and tristomodoeal polyps. Corallites 12-15 mm wide, up to 25 mm long, 7 mm deep, narrowing towards columella. Collines 3-6 mm, with groove above. Septa 10-12 per cm, 6 principals, continuing over colline or meeting in groove, principals about .75 mm thick exsert about 1 mm. Septa perforated, teeth coarse, directed horizontally. Columella well developed, 2-3 mm in width of closely twisted septal trabeculae.

45. *Mussismilia hartii* (Verrill).

Also *Protomussa hartii,* (Matthai, 1928), also *Mussa hartii,* (Verrill, 1902).

Described by Matthai (1928), page 270.

Cups irregular in shape, from 12 to 30 mm across, on ends of branches which are joined together along a varying part of their length. Similar in other respects to *M. brasiliensis,* but septal teeth thinner. Found only in Brazil.

Branching, branches dividing dichotomously, peritheca present or absent in varying quantity so that

branches vary in degree of separation. Corallites up to 30 mm long, 12-15 mm wide and about 10 mm deep. Walls sharply ridged, about 2 mm thick. Septa with many irregular teeth, thinner than M. brasiliensis, about 12-14 per cm, about six principal, up to 1.5 mm exsert. Columella of twisted septal trabeculae, well developed, 2 to 2.5 mm wide. Costae traverse greater length of corallites with slender teeth directed upwards.

46. *Mussa angulosa* (Pallas), (Plates 34, 35).

Also *Mussa lacera* (Pallas) Oken, (Verrill 1902).

Described by Matthai (1928), pages 204-208.

Heavy short branches ending in cups up to 12 cm long and 4.5 wide. Walls 6-8 mm thick. Septa have strong teeth pointing obliquely upwards. Toothed ridges continuous with the costae run lengthwise down branches. Found in the Bahamas and the West Indies, more rarely off the Florida Keys.

Branches divergent, heavy, large, calices forming convex upper surface. Valleys often constricted between columellar centers. Up to 12 cm long and 4.5 cm wide, down to 2 cm width between centers. Walls 6-8 mm thick, often angular. Septa 8 per cm, four or five principals sloping to meet columella. Septal margins with about 9 large blunt teeth, directed obliquely upwards, upper ones 4 mm long and 3 mm wide at base, sides spinulose. Septa exsert up to 6 mm, with two teeth on exsert portion. Columella well developed, centers 4-5 mm in width, made of thin interlaced trabeculae. Costae continuous with septa extending down wall, with upwards directed teeth.

47. *Isophyllastrea rigida* (Dana), (Plate 36).

Also *Mussa (Symphyllia) rigida* (Dana), (Verrill 1902).

Described by Matthai (1928), pages 263-268.

Small boulders. Cups polygonal and irregular in shape. Septa have 6-8 large teeth on their edges and extend over the walls. Wall about 3 mm thick, cups about 10 mm across, but may be much longer. Found in the West Indies, Bahamas, Bermuda and the Florida Keys.

Hemispherical, small, evenly convex, with broad attachment on lower surface. Cerioid. Calices tend to be polygonal. Mono-, and di-stomodoeal. Monostomodoeal calices 10-12 mm deep. Collines 2-4 mm thick with faint groove or ridge on upper surface. 25-30 septa in single corallites, 5-8 meeting the columella, thicker (1-1.5 mm) towards wall, narrow and almost vertical edge. Margins with 6-8 coarse teeth, lower ones larger, directed obliquely upwards. Sides of septa rough. Septa meet in groove or continuous over ridge, exsert to 1.5 mm, exsert portion toothed. Columella feeble, of loosely interlocking trabeculae.

48. *Mycetophyllia lamarckana* (Edwards and Haime), (Plates 37, 38).

Described by Matthai (1928), pages 250, 255.

Forms rather flat growths, either stalked or completely encrusting on old rock. Chocolate ground color, but frequently overlain with bright green. Valleys interconnected and walls tend to disappear in older corals. Septa toothed. Two or three parallel vertical toothed strips run lengthwise in the valleys.

Sub-turbinate or encrusting, pedicelled or not. Valley continuous, sinuous. Colline disappears partly in older coralla. Valley 12-15 mm wide, about 10 mm deep. Colline 2-3 mm thick, sometimes up to 5 mm, ridged or slightly grooved. Septa 8-10 per cm, 4 or 5

extending further into valley. Larger ones with 7-9 teeth, directed obliquely upwards. Slightly exsert, exsert ends toothed. Continuous over colline. Sides sometimes rough. Columella absent but septa converge towards centers, which are connected by 2 or 3 toothed lamellae. Thin epitheca covers under surface to within 10 mm of edge.

49. *Isophyllia sinuosa* (Ellis and Solander), (Plate 39)

Also *Isophyllia fragilis* (Dana), and *Isophyllia dispsacea* (Dana), (Verrill 1902).

Described by Matthai (1928), pages 237-247.

Color variegated with patches of lavender, bright green and white. Frequently bright green is predominant in the Florida Keys.

Medium size, massive, with short stalk, up to 6 or 8 inches. Valley continuous, lobes radiating from center, average width 22 mm widening towards rim, up to 35 mm, depth 8-10 mm. Valley becomes discontinuous in older colonies, losing radial arrangement. Circumscribed corallites possess one or two columellar centers. Colline usually ridged, sometimes with shallow groove above, swollen at base, 3-8 mm. Septa 7-9 per cm, 4 or 5 principal, very sloping margins which have 6-10 slender coarse teeth, lower ones larger, directed obliquely upwards, sides spinulose. Septa thicker towards columella, usually 2 mm. Principals exsert to 5 mm at edge of corallum, elsewhere 2 mm. Septa continuous over colline or meet in groove, extending to pedicel. Thin epitheca over non-calicinal surface except within 10 mm of edge. Variety dipsacea more spinous and heavier corallum, collines and septa thicker so that septa appear more crowded. Variety fragilis less spinous and lighter corallum, collines and septa

thinner, hence appearing less crowded. Calices deeper and steeper.

50. *Isophyllia multiflora* Verrill, (Plate 40).

Also *Mussa (Symphyllia) annectens* (Verrill 1902)

Described by Matthai (1928), page 248.

Similar in most respects to *I. sinuosa.* but greener in color, smaller, more singular cups, fewer and narrower valleys, walls thinner, septa more crowded, thinner and less protruding.

Smaller than I. sinuosa. Valleys shorter and narrower, average 14 mm wide up to 20 mm, less open. Colline thinner. Septa 11-12 per cm, 4 or 5 principal, thinner, less exsert. Columella less developed. Of loosely interlocked septal trabeculae.

51. *Eusmilia fastigiata* (Pallas), (Plate 41).

Also *Eusmilia aspera* (Dana), (Verrill 1902).

Described by Matthai (1928), page 190.

Branched with cups at ends of branches. More or less oval, up to 35 mm long, with sharp rim. No teeth to septa. Small toothed ridges extend from septa down outer part of cup and branch. Deep brown in color with greenish cup ringed with whitish tentacles. Florida, Bahamas and the West Indies.

Branching. Corallites with mono-, to tri-stomodeal polyps, often triangular. Valley up to 35 mm long. 8-13 mm wide, 8 mm deep. Wall 2 mm thick with sharp rim. Septa 15-18 per cm, 7-9 principals, 3.5 to 4 mm broad, thickening to 2 mm at wall, exsert to 2.5 mm. Subsidiaries thinner and less exsert. Margins entire sides with granular triae. Columella of closely twisted trabeculae, 1 mm broad, sharp above with wavy, often continuous ridge. Costae extend greater length of branches, irregularly toothed.

52. *Millepora alcicornis Linnaeus.*

The "stinging coral" is not a true coral, but is included here on account of its superficial similarity and its extensive distribution throughout the whole of the western Atlantic coral reef area. The general form varies from an encrusting growth over dead sea whips or shells, to a branching structure, which may grow out from the encrustation. The branches may resemble the staghorn coral, *Acropora palmata* in miniature. Sometimes a flattened frondlike or handlike growth takes place. The entire surface is covered with minute holes, barely visible to the naked eye, arranged in numerous groups of five smaller ones around a central larger one. Though these holes project the small polyps. The larger gastrozooids or feeding polyps project through the larger holes and the slimmer club-ended dactylozooids or stinging polyps arise from the smaller holes. The color varies from light orange yellow to dark brown.

GLOSSARY OF PRINCIPAL TECHNICAL TERMS USED IN CORAL TAXONOMY

basal plate:	The lower part of the coral cup, separating the polyp from the substrate.
calice:	The upper or open end of the corallite or coral cup.
centers:	Regions in a series which correspond to the centers of calices.
cerioid:	Form of colony when corallites or individual coral cups are closely pressed together and directly united by their walls, resulting in polygonal cups or calices.
coenenchyme:	Coral skeleton formed outside the wall of the cup or corallite.
coenosarc:	The soft part of the polyp which lies against the outside of the coral wall or cup.
columella:	Central axial structure formed from inner ends of septa.
compound:	Used to describe trabeculae composed of a series of bundles of sclerodermites or centers of calcification.
corallite:	The coral structure or cup formed by an individual polyp in the colony.
corallum:	The entire coral formed by a colony.
costae:	Continuations of the septa beyond the wall or theca.
dendroid:	Spreading branches, each a single corallite.
dissepiment:	Horizontal plates between septa or costae cutting off older, lower, parts of skeleton and supporting the polyp.
edge-zone	Part of the polyp which extends beyond the wall of the cup over the general coral surface.
encrusting:	Coral growth which forms thin continuous sheets directly attached to the substrate.
endotheca:	Consists of intrathecal dissepiments or horizontal plates within the cup or coral wall.
epitheca:	The vertical coral wall rising from the basal plate.
essential:	A columella similar in origin to pali. May be a group of twisted rods or fused into a single style.

exothecal:	Extrathecal dissepiments or horizontal plates outside the cup or coral wall.
exsert:	Margins of septa higher than the theca or coral cup.
extratentacular:	When buds are formed from the edge zone or the soft part lying outside the ring of tentacles.
fan system:	Arrangement of trabeculae inclined outwards from an axis of divergence. Several fan systems may exist in one septum.
fenestrate:	Septum of loosely connected trabeculae with pores of perforations between trabeculae.
flabelloid:	Meandroid corals with a single linear series or row of polyps.
foliaceous:	Branching in thin expanded sheets.
fossa:	Central cavity of a corallite or cup.
granulations:	Where sclerodermites or centres of calcification inclining outwards emerge at the surface of a septum.
hydnophoroid:	Corallite centers arranged around conical hillocks.
intratentacular budding:	Buds formed from that part of the polyp surrounding the mouth and ringed by the tentacles.
orâl disc:	That part of the coral polyp surrounding the mouth and ringed by the tentacles.
lamellar:	Columella is a vertical plate, free above, lying lengthwise in the long axis of the elongated corallite.
laminar:	Septum formed of trabeculae closely united to form a continuous sheet.
massive:	Forming thick masses.
meandroid:	Corallites forming groups or series within common walls, so as to form valleys.
pali:	Inner ends of septa, separated.
paratheca:	Wall formed from dissepiments.
parietal:	Columella formed by intermingling of trabeculae from inner margin of septa.
peritheca:	Extrathecal skeleton deposited by coenosarc.
phaceloid:	Parallel branches forming clumps or tufts.
plocoid:	Corallites united by peritheca and not directly by their walls.
ramose:	Branching colonies.

reptoid:	Budding from stolon-like expansions of edge zone.
sclerodermites:	Primary units of skeleton. Centres of calcification with their fascicles of fibres. Epitheca, basal plates, and dissepiments lack these. They are present in septa and related structures only.
septa:	Radiating vertical plates.
septotheca:	Formed by thickenings of outer parts of septa.
series:	A group of corallites within a common wall.
simple:	A trabeculum composed of a series of single sclerodermites.
stereome:	Layer of secondary thickening of septa or related parts.
synapticulae:	Rods joining adjacent septa.
synapticulotheca:	Similar to septotheca but not solid. Formed from synapticulae.
thamnasteroid:	Without definite boundaries and with confluent septa.
theca:	Wall uniting outer edges of septa.
trabecula:	A vertical series of sclerodermites or centres of calcification.
turbinate:	Inverted cone or top-shaped.

TAXONOMIC KEY TO GENERA OF LIVING WESTERN ATLANTIC CORALS. (After Vaughan & Wells)

(Descriptions leading to ahermatypic corals in brackets.)

1 Septa laminar or rudimentary consisting of relatively few simple (rarely compound) trabeculae strongly inclined from axis of divergence (Suborder ASTROCOENIIDA) ... 2
Septa laminar or fenestrate, well developed, consisting of numerous simple or compound trabeculae slightly inclined from the axis of divergence ... 5

2 Peritheca almost invariably absent. Septal margins beaded. (Family ASTROCOENIIDAE) ... 3
Peritheca extensively developed ... 4

3 Septal margins with well marked dentations. Corallum cerioid ... *Astrocoenia*
Septal margins smooth or minutely dentate. Corallum plocoid ... *Stephanocoenia*

4 Peritheca nonporous, solid, or vesicular (Family Seriatoporidae) ... *Madracis*
Peritheca porous, ventriculate (Family Acroporidae) *Acropora*

5 Septa consist of one or more fan systems of simple or compound trabeculae, porous or solid, margins beaded or dentate ... 6
Septa consist of one fan system of mostly simple trabeculae. Margins mostly smooth ... 29

6 Septa fenestrate composed of simple trabeculae, but often appearing laminar in later stages, more or less porous, margins beaded; simple synapticulae present. (Suborder FUNGIIDA) ... 7
Septa laminar, nonporous, margins dentate, sometimes minutely; synapticulae absent. (Sub-order FAVIIDA) 9

7 Septa fenestrate in young stages and higher cycles, laminar in later stages (Super family Agariciodae ... 8
Septa fenestrate and porous in all stages (Family Poritidae) ... *Porites*

8 Wall septothecal in ephebic stage, sometimes reduced or absent. Septa of simple trabeculae, laminar. (Family Agariciidae) ... *Agaricia*
Wall synapticulothecal. Fenestrate structure marked (less so in later stages). Septa of simple and compound trabeculae, more or less porous. (Family Siderastreidae) *Siderastrea*

9 Septa consist of one or two fan systems of trabeculae. Septal teeth never very large and coarse 10

Septa of more than two fan systems of trabeculae. Septal dentations large and coarse. (Family Mussidael) 25

10 Septal trabeculae simple or compound. Margins strongly dentate 11

Septal trabeculae simple, in one fan system. Margins minutely dentate 21

11 Septal dentations regular. (Family Faviidae) 12

Septal dentations irregular. Reptoid budding. (Family Astrangiidae) 18

12 Intratentacular budding. No directive mesenteries except in young polyps. (Subfamily Faviinae) 13

Extratentacular budding. Directive mesenteries in all polyps (Subfamily Montastreinae) 16

13 Colonies polcoid, corallites united nearly to tops by peritheca. Costate ....*Favia*

Colonies meandroid, series sinuous, usually long 14

14 Septa lack internal lobes. Trabecular linkages between Centers ....*Diploria*

The larger septa with internal lobes, which are small and narrow. Linkages trabecular or lamellar 15

15 Trabecular linkage, walls mostly parathecal, valleys broad ....*Manicina*

Lamellar linkage ....*Colpophyllia*

16 Phaceloid, paliform lobes, papillose columella present. Exotheca not vesicular ....*Cladocora*

Plocoid, parietal spongy columella, vesicular exotheca 17

17 Peritheca costate, exotheca vesicular, septal margin regularly dentate ....*Montastrea*

Peritheca almost without costae, very vesicular, appearing blistered ....*Solenastrea*

18 Colonies reptoid. Septa of first two or three cycles obscurely dentate and exert .... (19)

Colonies plocoid, united basally by peritheca 20

(19) Corallites united by thin stolon-like expansions. Columella papillary ....*(Oulangia)*

Corallites united by some peritheca. Columella feeble *(Phyllangia)*

20 Columella papillose or spongy. All septal dentate ....*Astrangia*

Columella appears lamellar. Only lower cycles of septa obscurely dentate ....*(Colangia)*

21 Dendroid. Extratentacular budding; Peritheca dense, solid. Endotheca subtabular. (Family Oculinidae) 22
Meandroid. Intratentacular budding. Peritheca dense, if developed. Endotheca vesicular. (Family Trochosmiliidae) 23
22 Columella parietal, feeble. Corallites filling with stereome. No pali ....*Madrepora*
Columella of twisted trabecular processes, well developed. Pali in irregular crown before first one or two cycles. Axial corallite absent ....*Oculina*
23 Peritheca absent, columella lamellar, if developed. (Subfamily Meandrininae) ....*Meandrina*
Peritheca dense, columella parietal (Subfamily Dichocoeniinae) 24
24 Corallite series mono- to tri-centric and short, united by peritheca ....*Dichocoenia*
Corallite series long, united directly by septothecal walls . *Dendrogyra*
25 Phaceloid colonies 26
Cerioid or meandroid 27
26 Septal dentations lacerate and irregular ....*Mussismilia*
Septal dentations regular ....*Mussa*
27 Cerioid, mono- to tri-centric. Feeble columella *Isophyllastrea*
Meandroid 28
28 Series long, lamellar linkage, Collines discontinuous, enclosing several series. No columella ....*Mycetophyllia*
Series short, trabecular linkage ....*Isophyllia*
29 Septa always laminar and nonporous, margins smooth, no snapticulae (Sub-order CARYOPHYLLIIDA) 30
Septa secondary thickened singularly porous, margins smooth or beaded. Synapticulae present (Sub-order DENDROPHYLIIDA) .... (56)
30 Corallite wall septothecal (Superfamily Caryophyllioidae) 31
Corallite wall epithecal (Superfamily Flabelloidae) .... (54)
31 Wall imperforate (Family Caryophylliidae) 32
Wall often perforate when first formed (Family Guyniidae) .... (52)
32 Endotheca absent .... (33)
Endotheca present .... (44)
(33) Corallum not entirely covered by the polyp. (Subfamily Caryophylliinae) .... (34)

Corallum entirely covered by the polyp. (Subfamily Turboliniidae) .... (43)

(34) Pali or paliform lobes present .... (35)
Pali absent .... (40)

(35) Pali in one crown before third cycle .... (36)
Paliform lobes, irregular, before third cycle .... *(Bathycyathus)*
Pali in two crowns before all but last cycle .... (37)
Pali in several crowns, indistinct, before all but last cycle, solitary, turbinate to trochoid .... *(Paracyathus)*

(36) Solitary .... *(Caryophyllia)*
Colonial, small phaceloid colony .... *(Coenocyathus)*

(37) Pali simple .... (38)
Pali of one crown unite in deltas. Corallum discoidal *(Deltocyathus)*

(38) Corallum turbinate to ceratoid .... (39)
Corallum globular or bottle shaped .... *(Peponocyathus)*

(39) Epitheca absent .... *(Trochocyathus)*
Epitheca present .... *(Tethocyathus)*

(40) Columella absent .... (41)
Columella fascicular .... (42)
Columella axially elongate with secondary thickened lammellar elements .... *(Oxysmilia)*

(41) Patellate .... *(Stephanocyathus)*
Turbinate .... *(Vaughanelia)*

(42) Columella crispate at surface .... *(Cyathoceras)*
Columella papillose .... *(Ceratotrochus)*

(43) Columella parietal, pali present .... *(Paradeltocyathus)*
Columella styliform, corallum trochoid .... *(Turbinolia)*
Columella lamellar appearance .... *(Sphenotrochus)*

44 Endotheca sparse and deep (Subfamily Desmophylliidea) (45)
Endotheca well developed 46

(45) Solitary .... *(Desmophyllum)*
Dendroid .... *(Lophelia)*

46 Mostly solitary. Colonies dendroid. Extratentacular budding (Subfamily Parasmiliinae) .... (47)
Colonial. Phaceloid. Intratentacular budding (Subfamily Eusmilliinae .... *Eusmilia*

(47) Paliform lobes absent .... (48)
Paliform lobes present .... (51)

(48) Columella feeble or absent .... (49)
Columella spongy .... *(Parasmilia)*

(49) Solitary .... (*Dungulia*)
Colonial .... (50)
(50) Subdendroid. Mature polyps not continuous .... (*Anomocora*)
Dendroid or phaceloid .... (*Solenosmilia*)
(51) Paliform lobes before third cycle .... (*Caryosmilia*)
Lobes before all but last cycle .... (*Asterosmilia*)
(52) Columella absent .... (*Schizocyathus*)
Columella present .... (53)
(53) Pali absent .... (*Guynia*)
Pali in one crown of six .... (*Stenocyathus*)
(54) Columella feeble or absent .... (55)
Columella parietal. Corallum turbinate-trochoid .... (*Gardineria*)
(55) Corallum cuneiform or compressed turbinate. No basal rootlets .... (*Flabellum*)
Basal rootlets developed .... (*Monomyces*)
(56) Septa normal in ephebic stage .... (57)
Septa according to Pourtales plan in ephebic stage .... (61)
(57) Solitary .... (58)
Colonial .... (60)
(58) Costae distinct .... (*Trochopsammia*)
Costae replaced by spines .... (59)
(59) Columella feeble .... (*Thecopsammia*)
Columella well developed .... (*Bathypsammia*)
(60) Corallum dendroid .... (*Enallopsammia*)
Corallum plocoid .... (*Tubastrea*)
(61) Solitary .... (*Balanophyllia*)
Colonial, dendroid .... (*Dendrophyllia*)

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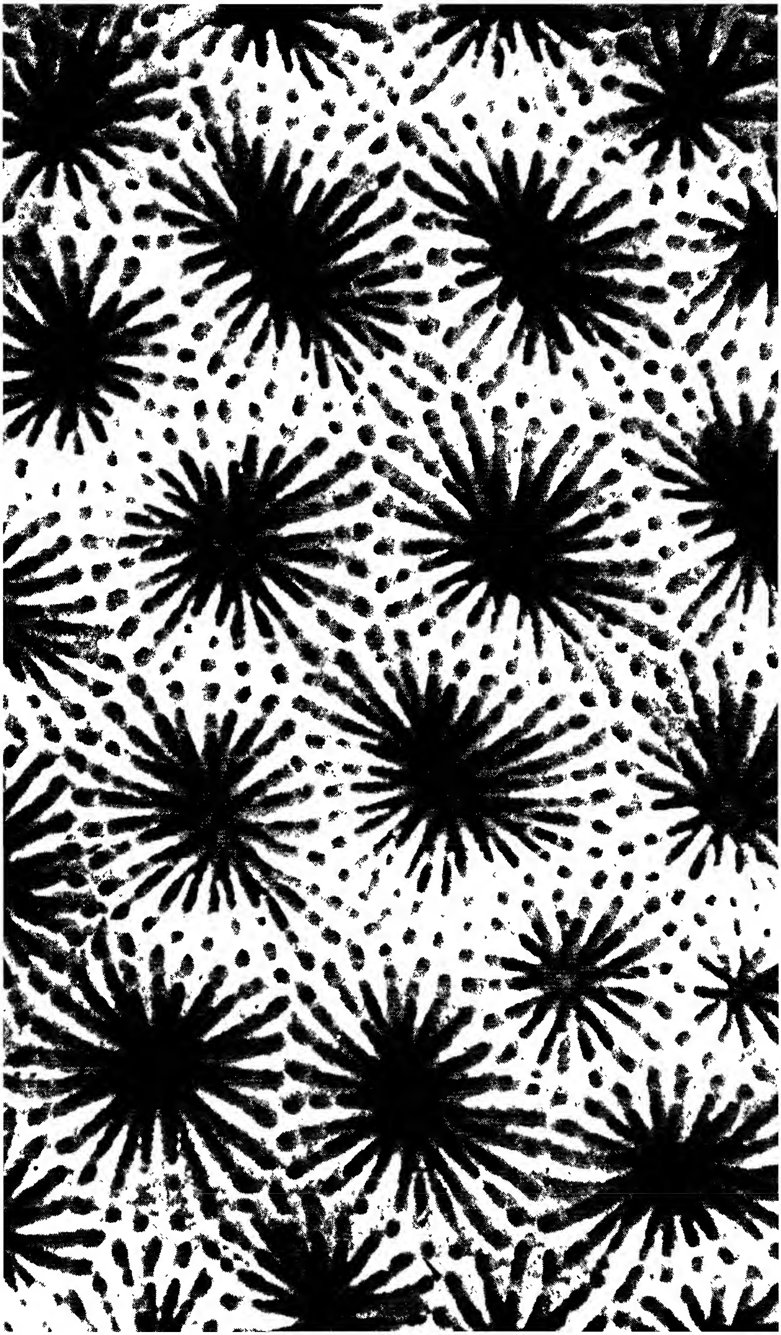
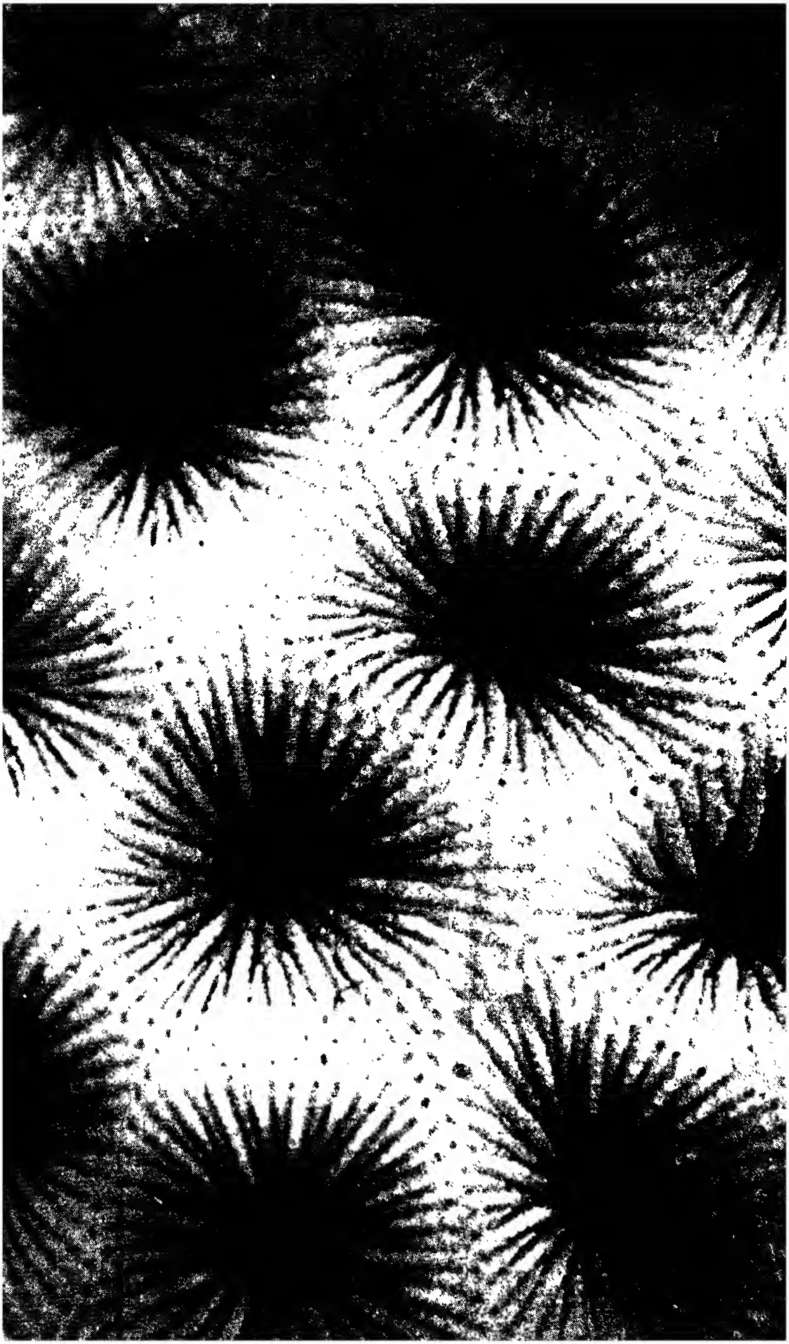
PLATES

24. Surface of *Solenastrea hyades* (Dana)	x 9	M.L. 8.31
25. Colony of *Montastrea annularis* (Ellis & Solander)	x 2/3	M.L. 8.41
26. Surface of *Montastrea annularis* (Ellis & Solander)	x 14	M.L. 8.41
27. Surface of *Montastrea cavernosa* (Linnaeus)	x 14	M.L. 8.34
28. Colony of *Oculina diffusa* Lamarck	x 1 1/2	M.L. 8.26
29. Surface of *Meandrina meandrites* (Linnaeus)	x 4	M.L. 8.48
30. Colony of *Meandrina brasiliensis* (Edwards & Haime)	x 1 1/2	Frank Lyman
31. Surface of *Dichocoenia stokesii* Edwards & Haime	x 14	M.L. 8.38
32. Part of a colony of *Dendrogyra cylindrus* Ehrenberg	x 1 1/3	M.L. 8.50
33. Surface of *Dendrogyra cylindrus* Ehrenberg	x 4	M.L. 8.50
34. Young stage of *Mussa angulosa* (Pallas)	x 2	M.L. 8.99
35. Older colony of *Mussa angulosa* (Pallas)	x 3/4	M.L. 9.85
36. Surface of *Isophyllastrea rigida* (Dana)	x 4	M.L. 8.105
37. Colony of *Mycetophyllia lamarckana* (Edwards & Haime)	x 1	M.L. 8.126
38. Surface of *Mycetophyllia lamarckana* (Edwards & Haime)	x 2 1/2	M.L. 8.97
39. Surface of *Isophyllia sinuosa* var fragilis	x 2 1/2	M.L. 8.101
40. Surface of *Isophyllia multiflora* Verrill	x 4	M.L. 8.42
41. Colony of *Eusmilia fastigiata* (Pallas)	x 2 1/2	M.L. 8.27





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